Forage Seed Research and Development in Ethiopia

Edited by
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Ethiopian Institute of Agricultural Research
Forage Seed Research and Development in Ethiopia

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Preface

Human population, cropping systems, and drought are constraining livestock feed supply and eventually productivity in Ethiopia. Though feed is available to a certain extent, in majority of cases, it is not in a position to satisfy quality for a higher productivity of our livestock sector. Available concentrate feeds and agro-industrial by-products are still at a very low level of supply to feed the existing livestock population. Besides availability, it is also true that, prices attached to livestock feeds are still on the higher side; hence, accessibility of feeds for most smallholder farmers is a question of the day.

Therefore, sustaining improved forage production through environmentally feasible means is essential to be able to boost livestock productivity in the country at both small-scale and commercial levels. At present, where livestock production are the realities of livelihood essentials, farmers are demanding a lot from research and development sectors to provide them with improved forage seeds, which are suitable for their farming systems. It is crystal clear that the demand is so huge. The question is where are we now in handling the demand?

First of all, we should be able to develop our capacity in terms of producing improved forage seeds of all types. Secondly, our intention to scale-up new forage technologies should have a structured position. Thirdly, the forage seed supply system should be established by involving essential actors in the sector. The rationale to hold a conference on forage seed research and development is aimed at isolating issues that are pertinent; and figuring out options to better serve livestock producers. This promise has been dealt in the conference by way of reviewing, presenting, and discussing experiences of forage seed production and development by the different stakeholders in the country. The other aspect of the conference was to promote seed and planting materials, which form our bases for scaling up forage technologies; ultimately contribute to achieve the targeted goals of livestock production in Ethiopia.

The Ethiopian Institute of Agricultural Research thanks with gratitude all those involved in the conference. I strongly believe that the contents of this publication yield the necessary information for readers to take up for various purposes.

Solomon Assefa
(Director General, EIAR)
Opening Speech

Solomon Assefa
Director General, Ethiopian Institute of Agricultural Research

It is indeed a pleasure to join you and make an opening remark this morning on the *First National Workshop on Forage Seeds*. First, allow me to express my earnest appreciation for all of you for accepting our invitation to attend this workshop. This year the season was special as we move into implementation of the five-year growth and transformation plan of Ethiopia. As you all know agriculture will continue to be an engine of rapid and sustainable economic growth and social transformation for the years to come. Among other economic sectors, agriculture is more of poverty reducing, because the vast majority of people depend on agriculture.

Livestock are high value commodities, thus, they deserve special attention. High value commodities require more labor and offer more income to smallholders than low value agriculture suggesting a perfect fit for smallholders. Realizing this significance, the Ethiopian Government has formulated ambitious but achievable targets during the plan period for most of the high value commodities.

Experiences over the years clearly suggest that sustainable delivery of improved seeds is one of the key challenges in realizing agricultural development plans. Addressing such a challenge requires critical reviewing achievements, progresses, and designing the way forward. Despite suitable climatic conditions and wide range of agro-ecologies for forage seed production, we are not yet self sufficient in the supply of forage seed. Attempts over the years have failed mainly due to short of project-based initiatives that are supported by strategies and action plans.

Like any other input, forage seed is a concern of the various public institutions, private firms, and farmers’ organizations. The recent national reform in all public institutions has offered a good chance for the public institutions to revisit their service delivery and re-engineer their internal process towards better satisfaction of customers. I believe we have built a national consensus that business as usual has not helped us much justifying the urgency for reconfiguration of our thoughts and a new way of doing things to disengage
from poverty and enable the country to be among the middle income countries in the world. In line with the overall political and economic policy of the country and the reform we have gone through, we need to look into what could be done at different levels to fulfill the national demand in forage seed supply.

It is my impression that beyond domestic market, we also need to open up our eyes, explore global market opportunities, and develop competence in the regional market in terms of forage seed. As feed cost accounts for the major share in the cost of livestock production and forage development is one of the key interventions to transform the livestock sector. Within the aspects of forage development, the seed system is a strategic issue. In the course of your deliberations, I am expecting consensus and deliver clear strategic directions, action points, and tasks to be shared towards attaining national goal in terms of forage seed supply as part of the workshop recommendation.

I thank you all for showing interest to participate in this workshop and for your commitment in contributing towards the goal of the growth and transformation plan of the country. Hoping you successful deliberation for the coming three days, I now declare the First National Workshop on Forage Seed is officially open.
Livestock production takes a considerable part of the country's national income. Nevertheless, the sub-sector has not fully been exploited because of low productivity, which is the result of several factors, among which feed is the major one.

In the highlands of Ethiopia, grazing areas are shrinking because of the rapid expansion of cultivated land. The degraded and other marginal areas of are left with extremely inadequate feed with poor nutrition. During the dry season, crop residues of poor quality are used as maintenance feed.

In the lowlands, animal production is affected by drought and the resultant feed supply challenges. Under such conditions it would be hard to expect the livestock sector to play positive roles that contribute to attain sustainable livelihoods of the farming and pastoral communities. As such feed scarcity, in terms of quantity and quality is recognized as a challenge affecting the livestock sector in Ethiopia. One of the strategic interventions is to promote production of improved forage species wider adaptability. These forage species provide adequate and high quality protein feed to complement lower quality crop residues. They are also important in soil conservation, and maintenance of soil fertility.

In Ethiopia, forage development started through the introduction of improved forage species. However, the lack of seed remains a constant constraint to wider adoption by farmers and others.

Forage seed production is less developed than field crops. Therefore, recognition must be given to the fact that inadequate seed production results to inadequate forage supply, which in turn, results in poor animal productivity. Today, we are here to assess the status, identify constraints, and options for sustainable forage seed production and supply. I am confident that our deliberations in this workshop will lead to practical recommendations for the promotion of national forage seed production. The recommendations from this workshop could also be achieved through a continuing commitment of various stakeholders. These include:

Keynote Address

Alemayehu Mengistu
Addis Ababa, Ethiopia, E-mail: alemayehumengistu@yahoo.com
1. **Policy initiative by the government to encourage local forage seed production and supply**
   - Providing credit facilities to seed producers;
   - Promoting contract seed production by guarding purchase price;
   - Supporting forage seed production activities within cooperatives;
   - Reinforcing the extension efforts of new forage varieties through field demonstrations;
   - Maintaining seed security stocks;
   - Encourage research on indigenous plant materials and beyond; and
   - Develop appropriate legislation to forage seed variety release and certifications

2. **Increasing informal farmer based systems**
   - On farm participatory research on forage seed production systems;
   - Broadened appreciations on the multiple role of forages; and
   - Initial seed multiplication and seed availability

3. **Increasing formal sector involvement**
   - Maintaining a commitment to develop, register and release new high yielding varieties;
   - Initiating basic seed production of varieties; and
   - Stimulating involvement of the private sectors

4. **Proper legislations and regulations**
   - Develop appropriate legislation;
   - Ensuring that the technical procedures are flexible and appropriate to forage varieties, for example, for variety release and certification; and
   - Ensuring that the seed quality standard are realistic in terms of species characteristics and the production capability of local farmers

5. **Formation of farm managed systems**
   - Suitable institutional arrangement;
   - Selection of pioneer seed production;
   - Identification of distribution channels;
   - Need for financial capacity to trade in seed; and
   - Facilities for processing and storage

6. **Role of research, higher learning institute, extension, international centers and NGOs**
   - Conducting research, training and extension in forage seed production;
   - Coordinating research, training and extension with regions;
   - Develop projects and programs to improve legislation, production and supply systems; and
   - Exchange of germplasm materials and beyond
7. **Proper linkage and support needs**
   - Involvement of various national stakeholders;
   - Linkage of forage seed production, supply and market systems;
   - Training technical personnel and farmers;
   - Research effort on farm managed forage seed systems;
   - Exchange of information through publication, newsletters, proceedings and journals; and
   - Networking as joint effort to strengthen national forage seed programs

Mr. Chairperson, the above-mentioned policies and institutional issues should be noted and forwarded to the concerned government officials and various stakeholders through our guest of honor for proper action.

Finally, I wish all participants to look forward to productive, stimulating, and enjoyable workshop.
Retrospects and Prospects of Forage and Pasture Crops Research in Ethiopia

Getnet Assefa
Ethiopian Institute of Agricultural Research (EIAR),
P.O. Box. 2003, Addis Ababa, Ethiopia

Introduction

In most tropical countries, feed is the primary constraint limiting livestock production and productivity, which is reflected by the low supply of meat, milk, drought power and other animal products in these countries. In Ethiopia, the low per-capita meat and milk consumption below African average and importation of animal products such as milk, in spite of owning huge livestock population, are clear indicators of low livestock productivity being mainly triggered by feed shortage. Since the last few years the price of meat, milk and live animal is increasing beyond normal expectations and this trend is likely to continue for the coming some years. This is mainly attributed and aggravated by the increased population and critical feed shortage accompanied by drought and natural disasters, and to some extent by global financial and economic crises. Similarly, there is also skyrocketing price of feed of all sorts including roughages, agro-industrial by products and concentrate compound feeds contributing to the increase prices of animal products.

Natural pasture, after math grazing and crop residues are the major sources of roughage in most parts of the country. The total annual feed produced from grazing lands and crop residues are not adequate to supply maintenance level of feeding for the existing livestock population. This has resulted critical seasonal feed deficits, weight loss and in some cases animal death consigning with drought in many part of Ethiopia every year.

This critical feed shortage amidst high demand for animal and animal products calls to look improving the supply and availability of feed. In this regard, the primary strategy should be to intensify the efficiency of using the available feed resources through improved management, production, conservation, and utilization. This should be supplemented with cultivated forage crops by growing through the different proven and recommended technologies in the farming system, which is an extremely important step if there is a need to increase livestock production in Ethiopia. Cultivation of improved forage crops is relatively cheaper than purchasing concentrate supplements, more appropriate to the Ethiopian livestock production system and environmentally friendly.
Improved forage crops have diversified advantages. The primary benefits are to produce high amount of quality herbage to be used as feed for livestock. On the other hand they complement crop production by maintaining soil fertility by fixing nitrogen or when used as mulch. In addition, forage crops could be grown as a component in integrated natural resource management to prevent soil erosion, control weeds, pests, and diseases. Generally improved forage crop production is feasible, appropriate, and sustainable feed source globally. This paper highlights forage and pasture crops research and the major challenges and opportunities for development under Ethiopia condition.

**Variety Development**

Several forage species and accessions were evaluated in the different agro-ecologies of Ethiopia since the start of forage and pasture research as old as the establishment of agricultural colleges and the Institute of Agricultural Research (IAR). Despite that, major principles to be applied for variety and species development for forage crops were not properly established in the national research system. Most of the research activities were limited to preliminary adaptation and agronomic practices. Unlike food crops research, with better and well-organized structure and national variety releasing mechanisms, the system for forage crops were not established for releasing varieties. Due to this forage, development was limited to government and commercial large-scale livestock farms, research centers, and universities.

Significant number of important forage grasses and legumes have been collected in the different agro-ecologies of the country and systematically conserved by International Livestock Research Institute (ILRI), the then ILCA (Table 1) (Getahun et al, 2002). Even though some efforts have been made in screening and evaluation of these local collections, the majority of the research activities and recommended forage species have been based on exotic species mainly from Australia, New Zealand, America, Mexico, Europe, and some African countries like Kenya through the various development projects, provisions to agricultural research, agricultural extension and universities.

**Major selection criteria**

In Ethiopia, forage variety development has been entirely limited to selection of desired traits at species and or accession level. Advanced forms of breeding and variety development is totally absent in the system. During selection, a species or accession is evaluated for many desirable traits as possible and for their suitability to fit into the diversified production systems and agro-ecologies. Therefore, the forage species needs to have as many desirable features as
possible to fit in to the particular targeted production system. Under Ethiopian condition, forage crops have been evaluated almost in all agro-ecologies with limited production characteristics. Major works have been done in the high and mid altitude areas that had better accessibility. Among others, the most important desirable characteristics of forage crops evaluated include:

- Ease of establishment – most perennial forage crops particularly in the cooler highlands has difficulties of establishment due mainly to environmental stresses and high weed competition. Hence, species that could be established easily are highly acceptable by users;
- Seed production potential;
- Biomass productivity – its re-growth ability and forage yield;
- Adaptations and persistency – ability to withstand drought, total length of production years, resistance to grazing, resistance to frost, salinity etc;
- Resistance to diseases and pests;
- Complementary benefits like their effect on soil fertility, to grow on marginal lands and stress conditions, suitability for soil conservation uses; compatibility when planted with various food crops and
- Forage quality – laboratory evaluation and animal responses The ultimate value of any forage is expressed in terms of yield of milk, meat, power etc, however, due to limitations in facilities, input supplies, and trained human power, only some species have been fairly characterized for their feeding value.

Table 1. Indigenous grasses, herbaceous legumes, and browse species collected in the different agro ecologies of Ethiopia and conserved at ILRI gene bank.

<table>
<thead>
<tr>
<th>Agroecological Zone</th>
<th>Grass species</th>
<th>Accession</th>
<th>Browse species</th>
<th>Accession</th>
<th>Legume Species</th>
<th>Accession</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arid and semi arid</td>
<td>10</td>
<td>13</td>
<td>6</td>
<td>10</td>
<td>24</td>
<td>59</td>
</tr>
<tr>
<td>Moist and sub moist</td>
<td>53</td>
<td>150</td>
<td>22</td>
<td>55</td>
<td>158</td>
<td>1151</td>
</tr>
<tr>
<td>Humid and sub humid</td>
<td>61</td>
<td>208</td>
<td>40</td>
<td>115</td>
<td>151</td>
<td>886</td>
</tr>
<tr>
<td>Total</td>
<td>124</td>
<td>371</td>
<td>68</td>
<td>180</td>
<td>333</td>
<td>2096</td>
</tr>
</tbody>
</table>

*Source: Getahun et al, 2002*

**Registered varieties**

Despite long years of improved forage research and development efforts in Ethiopia, official variety releasing procedures for forage crops were established since 2009. In spite of the absence of procedures and guidelines of forage species and varieties releasing and registration mechanism, as the demand by the farmers increased, some forage crops reach to the end users through various means and cultivated by farmers in the different agro-ecologies. Crop development department of the Ministry of Agriculture, crop variety register officially listed about 19 forage species as indicated in Table 2.
Table 2. List of forage species and varieties registered in the book of variety released, ministry of agriculture and rural development, crop development program.

<table>
<thead>
<tr>
<th>Species</th>
<th>Variety</th>
<th>Common names</th>
<th>Year of registration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grasses</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Avena sativa</em></td>
<td>CI-8237</td>
<td>Oats</td>
<td>1976</td>
</tr>
<tr>
<td><em>Avena sativa</em></td>
<td>Bonsa</td>
<td>Oats</td>
<td>2011</td>
</tr>
<tr>
<td><em>Avena sativa</em></td>
<td>Bona bas</td>
<td>Oats</td>
<td>2011</td>
</tr>
<tr>
<td><em>Phalaris aquatica</em></td>
<td>Sirossa</td>
<td>Phalaris</td>
<td>1982</td>
</tr>
<tr>
<td><em>Pennisetum purpureum</em></td>
<td>ILCA-16984</td>
<td>Elephant grass</td>
<td>1984</td>
</tr>
<tr>
<td><em>Chloris gayana</em></td>
<td>Massaba</td>
<td>Rhodes grass</td>
<td>1984</td>
</tr>
<tr>
<td><em>Panicum coloratum</em></td>
<td>Coloratum</td>
<td>Guinea grass</td>
<td>1984</td>
</tr>
<tr>
<td><em>Andropogon gayanus</em></td>
<td>Dirki Ayifera</td>
<td>Andropogon</td>
<td>2011</td>
</tr>
<tr>
<td><strong>Legumes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Triflium quartinianum</em></td>
<td>-</td>
<td>Clover</td>
<td>1976</td>
</tr>
<tr>
<td><em>Vicia dasycarpa</em></td>
<td>Lana</td>
<td>Vetch</td>
<td>1976</td>
</tr>
<tr>
<td><em>Vicia villosa</em></td>
<td>Lalisa</td>
<td></td>
<td>2011</td>
</tr>
<tr>
<td><em>Vicia sativa</em></td>
<td>Gebisa</td>
<td></td>
<td>2011</td>
</tr>
<tr>
<td><em>Vicia narbonensis</em></td>
<td>Abdeta</td>
<td></td>
<td>2011</td>
</tr>
<tr>
<td><em>Lablab purpureus</em></td>
<td>-</td>
<td>Lablab</td>
<td>1984</td>
</tr>
<tr>
<td><em>Vigna unguiculata</em></td>
<td>Sewinet</td>
<td>Cowpea</td>
<td>2011</td>
</tr>
<tr>
<td><strong>Browse</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Chamaecytisus palmensis</em></td>
<td>-</td>
<td>Tagasaste, Tree lucerne</td>
<td>1992</td>
</tr>
<tr>
<td><em>Cajanus cajan</em></td>
<td>Dursa</td>
<td>Pigeon pea</td>
<td>2011</td>
</tr>
</tbody>
</table>

Source: MOARD, 2011

Nevertheless, these registered forage crops are few among many recommended forage crops, which some of them are cultivated and utilized by farmers in the different agro-ecologies. Table 3 shows the list of recommended improved forage crops for the different agro-ecologies of Ethiopia. They have different growth and adaptability features in either conventional cultivation, integrated with food crops or other production conditions in the farming systems. Recently forage variety development procedures and guidelines are developed and forage varieties are currently released.

**Agronomic practices**

Ethiopia has highly diversified agro-ecology mainly based on moisture (length of growing period) and temperature regimes, which ranges from arid and semi-arid lowlands to moist cool highlands and a high diversity of soil types (MOARD, 2005). This high diversity in agro-ecology and soil types is an opportunity to grow diversified crops and forage species adapted to temperate, Mediterranean, humid, dry, arid, and semiarid climates. On the other hand, when this forage species are grown in the different agro-ecologies and soils types, their agronomic requirements vary accordingly. Agronomic practices such as establishment methods, seeding rates/spacing, fertilizer application rates, food forage integration, weed and disease/pest control practices, harvesting stages and
conservation strategies for selected and widely cultivated annual and perennial forage crops are established in the major agroecologies under Ethiopian condition.

Table 3. List of recommended forage species for the different agro-ecologies of Ethiopia

<table>
<thead>
<tr>
<th>Forage species</th>
<th>Adaptations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grasses</strong></td>
<td></td>
</tr>
<tr>
<td>Avena sativa (Oats)</td>
<td>High to mid altitude</td>
</tr>
<tr>
<td>Pennisetum purpureum (Elephant grass)</td>
<td>Low to mid altitude</td>
</tr>
<tr>
<td>Chloris gayana (Rhodes grass)</td>
<td>Low to high altitude</td>
</tr>
<tr>
<td>Panicum coloratum (Colored Guinea grass)</td>
<td>Low to high altitude</td>
</tr>
<tr>
<td>Panicum maximum (Guinea grass)</td>
<td>Low to high altitude</td>
</tr>
<tr>
<td>Panicum antidotale</td>
<td>Low to mid altitude</td>
</tr>
<tr>
<td>Melinis minutiflora (Molasses grass)</td>
<td>Low to mid altitude</td>
</tr>
<tr>
<td>Sorghum sudanese (Sudan grass)</td>
<td>Low to mid altitude</td>
</tr>
<tr>
<td>Sorghum almum (Columbus grass)</td>
<td>Low to mid altitude</td>
</tr>
<tr>
<td>Brachiaria species</td>
<td>Mid altitude</td>
</tr>
<tr>
<td>Cenchrus ciliaris (Buffel grass)</td>
<td>Low to mid altitude</td>
</tr>
<tr>
<td><strong>Legumes</strong></td>
<td></td>
</tr>
<tr>
<td>Vicia species (Vetch)</td>
<td>High to mid altitude s</td>
</tr>
<tr>
<td>Trifolium spp, (annuals &amp; perennials clovers)</td>
<td>High to mid altitude</td>
</tr>
<tr>
<td>Melilotus altissimus</td>
<td>High to mid altitude</td>
</tr>
<tr>
<td>Lotus maiziculatus (Birdsfoot trefoil)</td>
<td>High - altitude</td>
</tr>
<tr>
<td>Medicago sativa (Lucerne, Alfalfa)</td>
<td>High to low altitude</td>
</tr>
<tr>
<td>Lablab purpureus (Lablab)</td>
<td>Mid to low altitude</td>
</tr>
<tr>
<td>Vigna unguiculata (Cowpea)</td>
<td>Mid to low altitude</td>
</tr>
<tr>
<td>Desmodium intortum (Green leaf Desmodium)</td>
<td>Mid to low altitude</td>
</tr>
<tr>
<td>Desmodium uncinatum (Silver leaf Desmodium)</td>
<td>Mid to low altitude</td>
</tr>
<tr>
<td>Stylosanthes spp (Stylo)</td>
<td>Mid to low altitude</td>
</tr>
<tr>
<td>Macroptilium atropurpureum</td>
<td>Mid to low altitude</td>
</tr>
<tr>
<td><strong>Browse Trees</strong></td>
<td></td>
</tr>
<tr>
<td>Chamaecytisis palmensis (Tagasaste, Tree Lucerne)</td>
<td>High altitude</td>
</tr>
<tr>
<td>Glinicida sepium (Glinicidia)</td>
<td>Mid to low altitude</td>
</tr>
<tr>
<td>Cajanus cajan (Pigeon pea)</td>
<td>Mid to low altitude</td>
</tr>
<tr>
<td>Calliandra calothyrsus (Calliandra)</td>
<td>Mid to low altitude</td>
</tr>
<tr>
<td>Acacia spp (Acacia)</td>
<td>Mid to low altitude</td>
</tr>
<tr>
<td>Leucaena species (leucocephala, diversifolia &amp; pallida)</td>
<td>Mid to low altitude</td>
</tr>
<tr>
<td>Atriplex canescens</td>
<td>Low altitude areas</td>
</tr>
<tr>
<td>Sesbania sesban (Sesbania)</td>
<td>Mid to low altitude</td>
</tr>
<tr>
<td><strong>Root crop</strong></td>
<td></td>
</tr>
<tr>
<td>Beta vulgaris (Fodder beet)</td>
<td>High altitude</td>
</tr>
</tbody>
</table>

Source Getnet et al, 2011
Forage seeds and planting materials

As feed becomes critically scarce in the different agro-ecologies and farming systems, livestock keepers are now a day’s perceived the importance of using improved forages as feasible option of availing feed for their animals. This has been proved in most farming systems all over the country. However, availability of seed and planting materials accompanied by subsistence production systems hindered forage development in most parts of Ethiopia. Unlike herbage/biomass, forage seed production requires specialized skills and facilities. As a result, forage seed production is managed by a few and well-organized farms. Very few preliminary research works have been conducted on forage seeds production and limited technologies are available. Flowering and seed setting potentials are the most important parameters in the screening process of most forage crops. Forage seeds most commonly produced at smallholder farmer’s level as part and component of the forage production. This is usually very small amount and often used for the farmer himself and in some cases for other few farmers. Common to other countries successful forage seed production is made by larger private or government seed enterprises at selected sites with skilled personnel and modern production and processing facilities.

Improved forage technology transfer and adoption

In spite of serious problems of feed shortage and large number of livestock, adoption and popularization of forage crops in Ethiopia is very poor. Scarcity of arable land, lack of effective extension systems in forage development in particular and livestock production in general, the socioeconomic situations of farmers and insufficient know how and awareness are the major reasons for not adopting forage crops (Benin et al., 2003, FAO, 2004). The present high demand and price of livestock and livestock products calls commercial livestock development plans primarily based on appropriate and cheaper quality feeding systems, like cultivated forage crops. For establishment of improved fodder production, the first most important prerequisite is availability of the forage seeds and planting materials of desired species. Equally important is a strong and well structured extension system, adequate budget and output targeted training to farmers and relevant stakeholders.

The experience of other successful countries in livestock development has also showed that livestock production was based on traditional ways of using natural meadows and grasslands. However, with the intensification of agriculture and commercialization of livestock production, the overall management of the system has been changed rapidly. Among others, the feed component has been intensified significantly. Changes in the feed production were focused in the use
of improved management practice of pasturelands, cultivation of productive fodder crops, processing of forages, and efficient conservation practices.

**Challenges**

- The expansion of croplands as a result of increased human population pressure and shrinkage of grazing lands aggravated feed shortage, which is the main cause of poor productivity of animals; on the other hand the demand for livestock products is rapidly increasing;
- The low genetic production potential of local animals and limited response to improved feeding particularly dairy animals;
- The subsistence way of living and poor socio economic situation of most farmers limits specialization of animal production, and focuses the use of livestock mainly as source of draft power;
- Limited know how, skills and capacity of forage seed production at national level;
- Inadequate availability of forage seeds of desired species;
- Limited extension services of forage production and utilization;
- Lack of well organized information in the demand, supply and marketing of forage seeds at different levels and absence of government and private enterprises in forage seed production; and
- Highly exaggerated and unaffordable prices of forage seeds and absence of well established production and marketing systems

**Opportunities and the Way Forward**

In view of the high demand for livestock development in Ethiopia for both food self-sufficiency and export market and striving agricultural growth and transformation plan, there is a good opportunity to improve livestock productivity. Improving feed supply through forage development is one of the major directions for feasible livestock productivity. For successful forage development in Ethiopia primarily there is a need to establish and strengthen a strong and sustainable forage seed system. In this regard reliable quality forage seeds of the desired species could be produced by private or government seed enterprises and small scale informal seed systems at cooperative and individual farmers’ levels.

Strong extension system on improve fodder production is very important as most of our smallholders are not well familiar to improved forage crops. The existing livestock extension is comparatively the weakest among other sectors. Livestock production requires large investment in which most poor farmers are not capable to afford, this calls the big roles required from financial institute to provide various services like credit and insurance.
Improved forage production is most often feasible and practical by livestock producers if the return from the investment is worth to invest. Therefore, extension of forage development is successful if it is packed with productive animals, better health services, product quality and value addition, and efficient marketing systems particularly targeted to smallholder farmers.

Generally, extension of forage development could focus on two scenarios. The first one is low input integration forage development where farmers establish forage as part of other routine activities with crops, marginal lands, and soil conservation strategies. The second one is targeting for more intensive livestock farmers with productive animals in which forage is cultivated conventionally with inputs such as fertilizers and irrigation.

Developing appropriate knowledge management and transfer strategies to ensure adequate capacity building of farmers thereby enhance the uptake and promotion of available feed technologies by the end users is crucially vital.

References


FAO (Food and Agriculture Organization of the United Nations), 2004. Livestock Sector Brief. Livestock information sector analysis and policy branch. FAO, Rome


MOARD (Ministry of Agriculture and Rural Development), 2005. Agroecological zones of Ethiopia. MOARD, Addis Ababa Ethiopia
The Evolution of Forage Seed Production in Ethiopia

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\end{itemize}

Introduction

The low productivity of Ethiopian livestock is a result of several limiting factors among which feed is the major one. For the country as a whole the existing feed does not meet the amount required by livestock. Natural pastures are the most important livestock feed resource. In most parts of the country natural grasslands are confined to degraded shallow upland/highland, fallow crop lands and soils that cannot be successfully cropped due to physical constraints such as flooding and water logging. They are low yielding and their production is insufficient and grazing conditions are only favourable for four to five months per year.

For several decades, grazing areas have been shrinking and likely to continue to do so because of rapid expansion of cultivated land for crop production to provide food for the ever-increasing human population. As a result, there is always likely to be limited feed resources for the existing livestock population. Therefore, selection of high-yielding and better-quality forage varieties, and development of improved forage production systems are critically important. In the past four decades, extensive research and development has been carried out in Ethiopia to test and evaluate the adaptability and performance of different forage species under different agro-ecological zones. An array of potential grass, legume and browse tree forage species have been selected for development programs. The selected species showed better yield and quality than those in the naturally occurring swards.

The introduction and development of selected forage species into the farming system is to help solve the severe forage deficit that the country is presently facing. However, the extension and promotion of improved forage production packages is lagging behind and not progressing as expected (except for a few development projects and programmes). This is due to a number of limiting factors; among which scarcity of forage seed is the foremost. In the past-recent years, a few agricultural development projects tried to multiply and produce forage seeds, but were not able to satisfy the demand.
The success of forage development depends upon the establishment of a local seed production system that can ensure the supply of adequate quantity of good quality forage seed. In Ethiopia, there are large potential areas with diverse altitude, climate, soil type and farming systems for the production of diverse forage species seeds. Despite the abundance of soil and climatic resources of the country, the progress in forage seed production has been insignificant. The Ethiopian Seed Enterprise (ESE), which has a national mandate to produce the required agricultural seed, is currently involved in the production of cereal, legumes and oil seeds. ESE has very limited involvement in forage seed production; producing oats and vetch for use by some commercial private and state dairy farms.

It is commonly observed that most smallholder Ethiopian farmers with the exception of some commercial-oriented dairy farmers are reluctant to accept the production of improved forage crops, because they prioritize their land and labour to the production of food and cash crops rather than forages. In spite of this, there is an increasing demand for forage seed especially from dairy farms. Government and non-government institution sponsored natural resource conservation programmes. These demands are for the most part met by national and international research institutions. Research and development activities on forage seed production carried out by institutions over the last decades in Ethiopia are outlined in the foregoing discussion.

Forage Research

The Ethiopian Institute of Agricultural Research (EIAR)
The Ethiopian Institute of Agricultural Research (Ex- IAR) started forage research as a national program in the mid 1960s. Research on forage seed began only in recent years, and due to lack of trained human power in seed technology and poor facilities its contribution in solving forage seed scarcity has been far below expectations. A list of some temperate (tropical highland) forage species and their seed yield potential is presented in Table 1 based on the research that was undertaken in the 1990s. Other observations, made on seed production potential of some forage crops in sub-humid altitude areas of Ethiopia indicates that Chloris gayana, at an optimum seeding rate and row spacing can yield up to 700 kg/ha of seed; Panicum coloratum, Desmodium uncinatum and Stylosanthes gave seed yields of about 500, 400 and 350 kg/ha, respectively.

In a trial conducted at Holetta Research Centre to determine the optimum maturity dates at which high seed yield would be obtained from four indigenous Trifolium species, the average seed yield was found to be 401 kg/ha and 433 kg/ha when harvested a week after flowering on red soil and two weeks after flowering on black soil, respectively (Table 2).
Table 1. Seed yield (kg/ha) of grass and legume species

<table>
<thead>
<tr>
<th>Species</th>
<th>Seed yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloris gayana</td>
<td>250</td>
</tr>
<tr>
<td>Panicum coloratum</td>
<td>200</td>
</tr>
<tr>
<td>Oats</td>
<td>1500</td>
</tr>
<tr>
<td>Vetch</td>
<td>600</td>
</tr>
</tbody>
</table>


Table 2. Average seed yield (kg/ha) of *Trifolium* species harvested at different stages of maturity on two soil types at Holetta

<table>
<thead>
<tr>
<th>Species/variety</th>
<th>Weeks after full flowering</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Red Soil</td>
<td></td>
</tr>
<tr>
<td><em>Trifolium</em> quartinianum</td>
<td>292</td>
</tr>
<tr>
<td>T. ruepellianum</td>
<td>385</td>
</tr>
<tr>
<td>T. steuderi</td>
<td>571</td>
</tr>
<tr>
<td>T. decorum</td>
<td>356</td>
</tr>
<tr>
<td>Mean</td>
<td>401</td>
</tr>
<tr>
<td>Black Soil</td>
<td></td>
</tr>
<tr>
<td><em>Trifolium</em> quartinianum</td>
<td>500</td>
</tr>
<tr>
<td>T. tembens</td>
<td>345</td>
</tr>
<tr>
<td>T. steuderi</td>
<td>379</td>
</tr>
<tr>
<td>T. decorum</td>
<td>343</td>
</tr>
<tr>
<td>Mean</td>
<td>392</td>
</tr>
</tbody>
</table>


**International Livestock Research Institute (ILRI)**

Recognising the need to promote access to forage seed, ILRI (ex-ILCA) established herbage seed unit in 1989. The unit aimed to address the problem of foundation seed in sub-Saharan Africa, and enhance the incorporation of forages in feed resources development program (Table 3). Over the course of the project years (1989-1993), major emphasis was placed on establishing basic seed
production to supply to the regions, and building a broad information base to support national seed production and development efforts. Although several forage species were identified as being promising for livestock feed, there was little information available about their seed production potential, methods of seed harvesting, threshing, and storage. ILRI Seed Unit has prepared a ‘fact sheet’ on herbage and seed crop husbandry techniques for major forage grass and legumes species and made available online at ILRI website. Besides its research programme, ILRI is distributing forage seed in small quantities together with information on their pedigree and agronomic characteristics. ILRI’s Seed Unit has also been involved in training of researchers and development agents on forage seed production, processing and post-harvest management.

Table 3. Number of forage species identified as promising for livestock feed by ILRI

<table>
<thead>
<tr>
<th>Forage category</th>
<th>Semi-humid</th>
<th>Sub-humid/humid</th>
<th>Highland</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasses</td>
<td>5</td>
<td>9</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>Legumes</td>
<td>13</td>
<td>34</td>
<td>25</td>
<td>72</td>
</tr>
<tr>
<td>Browse</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>47</td>
<td>32</td>
<td>101</td>
</tr>
</tbody>
</table>

Source: ILRI-Reports 1994, Ethiopia

The Forage Network in Ethiopia (FNE)
The Forage Network in Ethiopia was a professional society organized in 1980 to conduct and promote forage research and development work at a national level. It also assisted communications between researchers and development workers through its newsletter (FNE newsletter). Collaborator institutions were research, higher education, development organizations, and NGOs. The network conducted trials like natural grassland inventory and assessment, germplasm evaluation, multi-location trials on grass/legume mixtures, seed production, etc. FNE produced seeds of the more popular fodder crops like vetch, oats, alfalfa, dolichos, stylos, and arranged the distribution of forage seeds for national research and development programmes and beyond.

Arsi Rural Development Unit (ARDU, ex-CADU)
ARDU started forage seed production in the mid 1970's. The major emphasis was on the production of forage seed to be used by the dairy development cooperatives and associations. Major forage crop species whose seed were multiplied included grasses such as oats, Rhodes grass, Phalaris, cocksfoot, Panicum, Setaria, forage sorghums, buffel, and elephant grass; legumes like
Vetch, lablab and few seeds of alfalfa, *Desmodium*, *Trifolium spp* and few medics; and root crops such as fodder beets and turnips. In the late 1970s, commercial forage seed production was started by ARDU Seed Multiplication Centre; and target species were: oats, vetch, Rhodes grass, Panicum, and forage sorghums. Farmers were also contracted to produce oats, vetch and fodder beet. Table 4 shows the different forage species seed produced by ARDU, including seed yield and production sites.

ARDU was the only supplier of forage seeds throughout its project life. Its clients were EPID, IAR, ILCA, Alemaya Agricultural College, Jimma, Ambo, Debre Zeit Agricultural Schools and the National Soil and Water Conservation Programme. The pioneer work of ARDU under the framework of ‘systems approach’ involving crop, livestock, forage and seed production and extension activities paved the pathway for the subsequent establishment of the various development activities such as the Animal Feed and Nutrition Team (MOA); Livestock Development Projects like: FLDP, SSDD and NLDP; and National Resource-Soil and water conservation and other governmental and non-governmental organizations.

### Table 4. Forage seeds produced in Ethiopia under the CADU and ARDU projects

<table>
<thead>
<tr>
<th>Species</th>
<th>Area (ha)</th>
<th>Production (g/ha)</th>
<th>Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oats</td>
<td>50</td>
<td>10 – 15</td>
<td>K, D, B, ALF, G/K</td>
</tr>
<tr>
<td>Vetch</td>
<td>20</td>
<td>5 – 8</td>
<td>K, B, ALF</td>
</tr>
<tr>
<td>Fodder Beet</td>
<td>20</td>
<td>4 – 5</td>
<td>B, G</td>
</tr>
<tr>
<td>Rhodes</td>
<td>40</td>
<td>3 – 5</td>
<td>K, ALF</td>
</tr>
<tr>
<td>Panicum</td>
<td>20</td>
<td>3 – 4</td>
<td>K, ALF</td>
</tr>
<tr>
<td>Setaria</td>
<td>15</td>
<td>3 – 4</td>
<td>K, ALF</td>
</tr>
<tr>
<td>Phalaris</td>
<td>15</td>
<td>2 – 3</td>
<td>B, G</td>
</tr>
<tr>
<td>Cocksfoot</td>
<td>20</td>
<td>1.5 – 2</td>
<td>B, G</td>
</tr>
<tr>
<td>Buffel</td>
<td>10</td>
<td>1.5 – 2</td>
<td>D</td>
</tr>
<tr>
<td>Sorghum</td>
<td>15</td>
<td>6-8</td>
<td>K, D</td>
</tr>
<tr>
<td>Desmodium</td>
<td>5</td>
<td>2 – 3.5</td>
<td>K</td>
</tr>
<tr>
<td>Lablab</td>
<td>10</td>
<td>5 – 15</td>
<td>K, D</td>
</tr>
<tr>
<td>Trifolium</td>
<td>3</td>
<td>2 – 3</td>
<td>G</td>
</tr>
</tbody>
</table>

*Site: K = Kulumsa; D = Dera; B = Bekoji, ALF = Asela Livestock Farm; G/K = Gobe/Kofele

*Source: Alemayehu Mengistu, ARDU Annual Report 1972-1980, Ethiopia*
**Fourth Livestock Development Project (FLDP)**

Realizing the fact that the success of any forage development program is heavily dependent upon an establishment of seed production mechanism, the FLDP of the ministry of agriculture introduced the seed contract system of forage seed production in 1988 that extended up to 1993/94. The aim was to produce high-quality seed locally at a lower price in greater quantities. The system involved producing seed under contract with individual farmers and cooperatives. This system enabled the production of larger amount of seed per unit area and at lower cost of production per kilogram of seed as compared with that produced under daily paid labour system on large farms.

The seed contract system was legally agreed between the farmers and the project. Based on this contract, the project provided the initial seed at planting including the necessary technical advice and supervision. The project subsequently purchased the produced forage seed at a fixed price. On the other hand, farmers were obliged to follow the technical advice on forage seed production; and in return, produce and deliver clean seeds to the project in a specified time. The contract system placed emphasis on the production of herbaceous and tree legumes and a few grass species like Rhodes grass, buffel grass and *Phalaris*. Under this system of production, over 2,000 farmers (individual and cooperatives) were involved and the total annual production reached 150 tonnes, contributing substantially to reduced importation (Table 5). Apart from the contract seed system, forage seeds were also harvested on an opportunistic basis from forage plot primarily established for feed purposes. Herbaceous legumes, tree legumes and grasses were opportunistically harvested/collection from government ranches, state dairy farms; Ministry of Agriculture extension program nurseries and demonstration plantings around farmers’ backyard; over-sown grazing lands along road sides and stock exclusion areas, and from under-sown croplands.

The experience of FLDP on forage seed production of the various types of forages including grasses, herbaceous and tree legumes are shown in Tables 5 and 6. Due to its large amount of forage seed production capacity, the FLDP was able to promote the forage development strategies in a wide range of agro-ecological zones and farming systems. FLDP trained its senior staff, as well as the development agents (DAs) and farmers in forage seed production techniques. It also produced a manual on forage seed production.
Table 5. Seed production by Fourth Livestock Development Project (tonnes) under farmer's contract, and from existing plantings in government ranches and nurseries

<table>
<thead>
<tr>
<th>Period</th>
<th>Local production</th>
<th>Imported</th>
<th>Total</th>
<th>Imported (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986/87</td>
<td>0.7</td>
<td>0.7</td>
<td>1.4</td>
<td>100</td>
</tr>
<tr>
<td>1987/88</td>
<td>7.6</td>
<td>8.7</td>
<td>16.3</td>
<td>53</td>
</tr>
<tr>
<td>1988/89</td>
<td>37.9</td>
<td>18.7</td>
<td>56.6</td>
<td>33</td>
</tr>
<tr>
<td>1989/90</td>
<td>83.2</td>
<td>29</td>
<td>112.2</td>
<td>26</td>
</tr>
<tr>
<td>1990/91</td>
<td>80</td>
<td>20</td>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>1991/92</td>
<td>80</td>
<td></td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>1992/93</td>
<td>100</td>
<td>12</td>
<td>112</td>
<td>10</td>
</tr>
<tr>
<td>1993/94</td>
<td>150</td>
<td>10</td>
<td>160</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Source: Alemayehu Mengistu, 1994- World Bank Progress Report, Ethiopia


<table>
<thead>
<tr>
<th>Grasses</th>
<th>Yield (kg/ha)</th>
<th>Herbaceous Legumes</th>
<th>Yield (kg/ha)</th>
<th>Tree legumes</th>
<th>Yield (g/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oats</td>
<td>1,500</td>
<td>Vetch</td>
<td>1,000</td>
<td>Sesbania</td>
<td>1,500</td>
</tr>
<tr>
<td>Rhodes</td>
<td>400</td>
<td>Lablab</td>
<td>500</td>
<td>Leucaena</td>
<td>2,000</td>
</tr>
<tr>
<td>Buffel</td>
<td>150</td>
<td>Cowpea</td>
<td>800</td>
<td>Tree lucerne</td>
<td>1,500</td>
</tr>
<tr>
<td>Phalaris</td>
<td>300</td>
<td>Axillaris</td>
<td>400</td>
<td>Pigeon pea</td>
<td>1,000</td>
</tr>
<tr>
<td>Panicum</td>
<td>300</td>
<td>Siratro</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Setaria</td>
<td>300</td>
<td>Desmodium spp.</td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stylos spp.</td>
<td>400</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Alemayehu Mengistu, FLDP Progress Report 1993/94

Smallholder Dairy Development Project (SDDP)
The SDDP started its operation in 1995. The forage component of the project aimed to train farm families to become self-sufficient in improved forage production and feed their dairy cows. SDDP adapted the FLDP's forage development strategies and seed production systems. The project contracted dairy farmers to produce forage seeds. It also produced and harvested seed from government ranches that were assisted by the project. Seedlings of tree legumes and cuttings of elephant grasses were raised in nurseries established in various locations. Forage seed produced by SDDP is shown in Table 7.
Table 7. Forage seed production by SDDPa

<table>
<thead>
<tr>
<th>Regions</th>
<th>1997 Area (ha)</th>
<th>Seed production (kg)</th>
<th>1998 Area (ha)</th>
<th>Seed production (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNNP</td>
<td>27.5</td>
<td>14575</td>
<td>5</td>
<td>5000</td>
</tr>
<tr>
<td>Oromiya</td>
<td>47.5</td>
<td>44825</td>
<td>57</td>
<td>58800</td>
</tr>
<tr>
<td>Amhara</td>
<td>62.5</td>
<td>53825</td>
<td>79</td>
<td>68600</td>
</tr>
</tbody>
</table>


*aThe majority the forage seeds produced shown are oats, vetch, Sesbania, Leucaena and tree lucerne*

**National Livestock Development Program (NLDP)**

NLDP which started in 1999 represented an important further step to improve the productivity of the country's livestock resources. The major objectives of NLDP were to achieve sustainable increases in household income. Assessment of forage seed produced by farmers, ranch, and nurseries at different regions, zones and weredas were conducted by NLDP. In 1999 the Amhara region produced 23290 kg, Oromia 53500 kg, Southern Nations Nationalities Peoples Regional State (SNNPRS) 2200 kg and Benishangul and Gumuz produced 930 kg forage seeds. On the other hand, some regions procured forage seed from other regions. The SNNPRS, Gambella and Afar purchased 1150, 920 and 870 kg of forage seeds from Oromia, respectively. The NLDP assisted with inter-regional forage seed procurement and a total of 92760 kg were distributed to project regions. The forage seed produced and procured consisted of oats, vetch, cowpea, Sesbania, Leucaena and tree lucerne.

**Current Forage Seed Production**

The current need for forage seed is expected to continue as the demand for feed increases to support the growing market demand for livestock. In order to support seed production farmers, private investors, government, NGOs and other partners need to play their share of responsibility in producing and supplying forage seeds. To meet the anticipated forage seed demand, strengthening the national capacity for forage seed production is highly needed.
Constraints to Forage Seed Production and Marketing

General
There are many reasons why forage seed production in Ethiopia remains at a low level. During implementation of FLDP, national forage seed production reached 150 tonnes per year but this was not sustained after the completion project. The major constraints include lack of financial incentives for seed prices; high cost of forage seed production by government agencies; lack of seed storage and transport infrastructure; poorly developed marketing system for forage seed; under-financing of the present system of contract seed production; low priority attached to forage seed production by farmers; lack of knowledge about forage seed production among extension staff; and lack of inoculants and shortages of basic seed supply are the main ones. Some of the critical constraints are discussed and elaborated in the following sections.

Lack of incentive for production
One of the major constraints to forage seed production is the lack of a financial incentives to promote forage seed production. As shown in Table 8, with the exception of SNNPRS and to a very limited extent the Amhara Region, the purchase prices for forage seed are still based on those used by FLDP and SDDP. Judging the majority of these prevailing prices, there is no real financial incentive to produce forage seeds in Ethiopia.

In the recent past and at present, there is little incentive for the production of forage seeds. This is because many of the previous development programmes supplied forage seeds at highly subsidized rates or for free in order to encourage uptake of the improved forages. Although understandable as it sounds, this policy had negative effect on promotion of sustainable seed production. In addition, although the government institutions had introduced a system of contractual seed growers, those programmes had failed to develop sustainable system of marketing. As could be learned from the projects history, contractual forage seed production system would not continue any longer when the projects phase out, simply because there were no funds available for purchase of seeds from the contract growers.
Table 8. Selling prices of forage seeds by region (Birr/kg)

<table>
<thead>
<tr>
<th>Type of seeds</th>
<th>Amhara</th>
<th>Oromia</th>
<th>Tigray</th>
<th>SNNPRS (1999)</th>
<th>SNNPRS (2001)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Grasses</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Vetch</td>
<td>3.5</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Lablab</td>
<td>2.5</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Cow Pea</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Pigeon Pea</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sesbania</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Leucaena</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Tree Lucerne</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Calliandra</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Desmodium</td>
<td>10</td>
<td>10</td>
<td>-</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Macrotyloma</td>
<td>5</td>
<td>-</td>
<td>5</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Alfalfa</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Stylo</td>
<td>8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Siratro</td>
<td>5</td>
<td>-</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td>2</td>
<td>1.5 to 2.0</td>
<td>-</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Fodder Beet</td>
<td>5</td>
<td>25</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Source: NLP Report, 2001; SNNPRS = Southern Nations Nationalities Peoples Regional State*

**High costs of production by government agencies**

The costs of seed production by government agencies at zone and wereda level are much higher than those for farmer-based production. This is because of their much higher labour costs and administrative overhead costs. High cost of production meant that forage seed could not be distributed to users at affordable price.

**Lack of sustainable marketing system**

In the past, after the completion of the various programmes or projects, funding simply ceased and zone agricultural bureaus (ZABs) were no longer able to purchase seed. This resulted in delays in disbursing monies to producers due to the inefficiency of regional, zone and wereda accounting procedures.
The present system of contract seed production

Under the previous-present system of contract seed production, the Regional Agricultural Bureaus (RABs) contract farmers to multiply seed and sell it back to the RAB. The RABs provided the initial planting seed and organised distribution and collection. This system has been used for a number of years but suffers from persistent funding problems since new funds have to be mobilised each year (either from the regional government or federal or donor sources), in order to pay the farmers. It also entailed heavy burden on the RABs in terms of transport and storage facilities. There are many stages in both the seed production and seed distribution systems, each of which requires both physical and financial transactions, and has the likelihood for delay. The organisational structure of a commercial seed industry in some cases can be simplified, as forage farmers can purchase seed directly from the Seed Growers Association or cooperatives. In the simplified system, there are only two links in the chain between seed grower farmers and forage producer farmers.

Options for seed production and marketing

Creation of an incentive to produce forage seed

The previous practice of most forage development programmes was to issue seed free of charge, in order to encourage their use, but this in effect removed any incentive for improved forage production. In recent years, regions have been offering a nominal price for forage seed in order to encourage some production, but those prices are still based on the previous FLDP and SDDP prices and were far too low to offer any real incentive. During a field visit to SNNPRS many years ago, it was observed that, in response to complaints of seed producers for low seed price and at the same time in order to encourage seed production, the RAB had introduced a significant increment in the seed purchasing prices. This had, as might be expected, resulted in a significant increase for production by farmers that was made available for purchase by the RAB. What was even more significant was that a farmer who had produced a total of 35 kg of forage seed was making nearly as much income from his seed production as that from milk production. This illustrates that there is a definite potential for a truly commercial small-scale forage seed production as long as marketing system is improved. There is a real need to agree on an increased level of prices and a new pricing structure, which brings about farmers’ satisfaction in terms of increased income.

Additional advantage of increased pricing structure is that it would help to encourage a move from opportunistic system of production towards specialist production system of forage seed, which would definitely help to increase the yield and quality of seed production. This is so because under the opportunistic system, the seed produced may well have a low germination percentage, due to lack of uniformity in seed maturity, caused by differences in tiller maturity at
harvest. Under the specialist system, the forage crop is actually planted for the purpose of seed production, and as such, tends to be given greater managerial attention, which is more likely to result in higher yields of high quality forage seed.

**Farmer-based forage seed production**

Farmer-based forage seed production is much lower in cost than wereda or Zone production due to much lower labour and overhead costs. However, collection and transport costs of farmer-based production are high, due to the scattered nature of the production. The cost of transport for seed collection, supply of inputs and supervision could be significantly reduced if greater efforts could be made to cluster seed producers initially into informal groups. These would then become the nuclei for Seed Grower Associations (SGAs). The intention would be that members of the SGA would bring their forage seed to one focal point for collection and that they would collect their inputs from that same point. This formation of SGAs would have several other benefits, in that the SGA would be in a far better position to negotiate seed prices than individual farmers and would also be a focal point for farmer training programmes, field days and etc.

**Forage seed production by government agencies**

Forage seed has been produced in nurseries and multiplication plots under the Zone agricultural bureau (ZAB) and the Wereda Agricultural Bureau (WAB) system. However, as stated above, this production system is comparatively high cost, due to higher labour costs and administrative overheads. There are opportunities for the ZABs to rationalise the present Wereda-based production, by concentrating efforts into fewer sites that are more efficient. This would reduce their operational costs, reduce the frequency of supervision and the transport costs incurred for the supervision. It should also be noted that, in general there is too much concentration on the production of grass seed as compared with that of legumes, which would be vital for promotion of the production of legume-based herbagés, and legume seed. There are two other options, which would help to reduce WAB costs, which are involving of local farmers or perhaps an SGA in a self-help scheme whereby they provide some labour and receive payment in kind or in the form of seed; and leasing of surplus land or spare lands (after initial rationalization) to SGAs, and payment for such a lease could be effected in kind (by seed).
Sustained improvement in the present system of marketing

Continue and improve on the present system of RAB marketing, through the formation and promotion of SGAs. This would be achieved by clustering the existing and additional forage seed producers, initially into informal groups, which would later be formalised into SGAs. This formation of SGAs would help to reduce transport costs and travelling time for supply of inputs, supervision and collection of seed. It must also be noted that the formation of clusters into groups and their formalisation into SGAs would almost certainly be a lengthy and time-consuming process, which would require a considerable extension input.

Greater involvement of the Ethiopian seeds enterprise (ESE)

Linkages have already been established with the ESE, which has agreed to be involved in forage seed production, particularly of those seeds, which are difficult to produce under small farm conditions. Considerable benefits could result from a greater involvement of the ESE. In addition, the use of the seed-testing facilities at regional and perhaps Zone level, would fulfill an important function and more importantly, avoid duplication of such facilities. It may also prove possible, to use the ESE seed cleaning facilities, for any necessary cleaning of forage seeds. This would require some adaptation of their existing machinery, but would be a better option than the purchase of new machinery, which might not be fully utilised. However, the ESE is a commercial organisation and its involvement is almost certain to be dependent on the level of profitability to be achieved from forage seed production. This would of course be greatly improved by any upward revision of forage seed prices. It is also possible that the ESE could become involved in the marketing chain. It is understood that the ESE has direct contact with the Weredas. Therefore, once the revolving fund had been set up, there would be considerable advantages to be gained, if the funds could be channelled through the ESE, direct to the Weredas. This would effectively short-circuit the lengthy chain of marketing and distribution. Additional incentives as far as ESE is concerned would be the introduction of a forage seed crop as a rotational break into their cropping system; and the harvesting and sale of any crop residues remaining after the harvesting of the forage seed, which would increase the return per hectare from the land involved.

Involving local businessmen

Significant progress towards commercialisation could be achieved, if local businessmen, who might be grain traders, local millers, or commercial farmers, could be involved in the chain of production and marketing of forage seed. It is suggested that this could be achieved, through the involvement of such businessmen to act as a focal centre for a cluster, group or a seed growers association. This innovative step would have immediate advantages, in that the businessmen would already have storage facilities and probably some form of transport, which would provide much needed storage and reduce RAB
expenditure on transport. The initial intention would be that the businessmen would act as middlemen between the farmer and the RAB zonal staff, and would gradually play a more important role, leading to a greater degree of commercialisation.

**Encouraging NGOs**
In order to achieve more flexibility, there would be some benefits to be achieved from the involvement of NGOs already involved in the use of forage, to carry out the role of co-ordination at Regional or Zone level. Some NGOs already have a considerable involvement in both forage and livestock production and the establishment of closer linkages between RABs and ZABs and WABS with those NGOs would certainly prove beneficial. Previous discussions with some NGOs have indicated that in some cases they have been able to work directly to the Weredas, if given the necessary clearance by the RABs. If such an arrangement could be negotiated, it would effectively remove two and possibly four links from the lengthy chain of forage seed marketing and distribution.

**Recommendations on the marketing of forage seed**

**Continue with the existing informal/ farmers based forage seed production system**
There is a definite scope for improving the existing system. The formation of SGAs would certainly help to ease some of the logistical problems. It would also help to reduce transport costs for collection of seed, provision of inputs, and supervision. It would also ease the problems of general extension work, in that the SGAs would be a focal point for extension agents and there would be a greater degree of clustering. In addition, the influence of the farmers-based seed production would help bring a more market-oriented approach to the existing system.

**Involving local businessmen**
It is considered that this innovative initiative represents the best way forward, towards the establishment of a commercial forage seed industry. The involvement of local businessmen into the chain of marketing and production would have the benefits of the introduction of a commercial outlook; the availability of seed storage; and the possible availability of some form of transport. These would lead to immediate advantages to minimize the constraints of storage and transport at zone and woreda level. The eventual intention would be for the businessmen to gradually play a more important role in the chain of production and marketing. This would obviously require some form of incentive, which could be achieved by providing a small handling charge or “mark-up”. 
Greater involvement of the formal forage seed production system/ESE
Considerable benefits could be obtained through a further strengthening and exploitation of the existing linkages established with the ESE. ESE’s further involvement in forage seed production will certainly depend on the proposed revision of forage seed prices. In addition to its production function, ESE could also play a very useful role in the marketing chain as the direct link at Wereda level and thus short-circuit the existing RAB system. However, ESE would not be able to offer the same degree of local contact with small farmers, as would be possible through a local businessman. This is because their main production from out-growers is from large commercial farms. The most immediate benefits to be obtained from a greater involvement of ESE, would be from access to their seed testing facilities as a back-up to regional and zonal testing facilities. It is also possible that if in the future there is a need for mechanical cleaning of forage seeds that the ESE might agree to the adaptation and use of some of their seed-cleaning equipment.

Greater involvement of NGOs
Several NGOs already have a considerable involvement in forage and livestock production. If it proves possible to involve those NGOs into some form of a coordination role at zone level, they would be able to inject some much needed flexibility into the present RAB system. It seems possible for NGOs to work directly with the Wereda, if they can get the necessary clearance from the RAB’s. There is no question that NGOs involvement in forage development and livestock production would be of considerable assistance in the development of a sustainable forage seed industry. In situations where the desired direct linkage of NGOs to Wereda level fails to materialize, it will still be very important to maintain, foster and develop linkages of NGOs at farmers level, as they do have some very definite advantages to offer, due to their close contacts with the farmers and experience in the fields of forage development and forage seed production.

Monitoring and evaluation
The objective of a monitoring and evaluation system of any project, or programme, is to measure the progress of a project or programme and to evaluate its successes, or in some cases, failures. In order to evaluate progress, the first step is to establish a starting point or baseline. This is essential as a basis for future comparison. With respect to forage production, the basic information required are types of strategy used; numbers of farmers per strategy; areas of forage grown, or lengths of rows grown in the case of fodder hedges; and present production levels. With respect to forage seed production, basic information required are number of farmers; types of strategy/system; numbers of nurseries/multiplication plots; forage species being grown; areas grown; quantities of seed presently being produced; and quantities sold and price
information. With respect to seed requirements, it would be extremely useful to get feedback on the major forage species used for each strategy, and the quantities of seed employed.

**Way Forward**

The following elements are considered as critical for a successful commercial forage seed production in Ethiopia.

**Identification of partners:** There is a need to identify national partners who are potential collaborators. These could be the potential forage seed producers, fodder and livestock producers who will buy the seeds; the Livestock Extension Service and farmers; the Ethiopian Seed Enterprise or the big commercial seed producer; the Ethiopian Seed Agency; the National Research Institutions; NGOs; private business; etc.

**National policy and regulation:** Formulation of a national policy to support the seed producers and partners in the operation system is important. Flexibility of the national policy to support local level forage seed production is necessary. For example, national policy and regulation may not allow sales of varieties that are not officially released by the national seed release committee.

**Need assessment:** Assess farmer’s needs, constraints and existing indigenous knowledge in target seed production areas. These need to be done before large production venture takes place as farmers are the potential end users of seed produced.

**Availability of variety for research:** The need for local and improved forage varieties for the start and replacement of obsolete varieties from time to time should be assessed and secured partly through forage seed research.

**Training and availability of training manual and guideline:** Training of technical staff on seed production and management, training of supervisors, DAs and farmers; provision of field manuals and guidelines is necessary.

**Extension efforts on forage seed production and distribution:** Promotion and dissemination of forage and seed production to seed producers and forage producers and users through the extension system should be strengthened.
Institutional linkages and support needs: To ensure continuity of forage seed production systems, institutional linkages should be established locally and outside the country. Each institution should have commitment along the chain from initial forage seed production to marketing systems.

Marketing: The demand of the consumer who in the case of seed is the farmer should be assessed. This is due to the fact that if the farmer doesn't believe the seed is best suited to his/her need, there will be no seed demand.

Economics of forage seed production: Any farmer entering the seed enterprise likes to maximize economic returns out of the business. Therefore, understanding the basis of forage seed production economics is crucial and important.

Concluding Remarks

Implementation of the recommendations contained in this report is expected to deliver good quality forage seed available at affordable prices; increased forage production in terms of both quantity and quality; and increased livestock productivity. The recommendations establish a methodology to achieve sustainable forage seed production in Ethiopia, leading to the development of a commercial forage seed industry which can sustainably supply forage seed with minimal government involvement. If successfully implemented, this will provide a model for forage seed production which would be suitable for replication throughout sub-Saharan Africa. “A country which does not produce its own agricultural seed is a country without agricultural technology of its own and ultimately a country without sovereignty” (in Alemayehu, 2006)
References

Forage Genetic Resources of Ethiopia

Solomon Mengistu¹ and Jean Hanson²

¹Ethiopian Institute of Agricultural Research, P.O.Box, 2003, Addis Ababa.
²International Livestock Research Institute, P. O. Box 5689, Addis Ababa

Introduction

The wealth of forage (and wild economic plants) genetic resource is subject to genetic erosion and in some areas to mass extinction due to human activity. Changes in traditional farming and open grazing systems threaten the survival of plant genetic resources. Climate change hazards, such as drought, extremes of temperature, landslides and incidence of widespread animal and plant diseases have a large impact on livelihoods and the environment at regional and global level. Drought is recurring every two to three years rather than every decade as before, especially in the lowlands of Ethiopia and Eastern Africa. This results threats to the valuable flora and fauna genetic resources leading to extinction; crop failures; decreased carrying capacity of the range vegetation with a consequent heavy livestock death, food insecurity and overall socioeconomic disruption. Thus, targeted germplasm collection, in-situ conservation of plants in priority gene centers and public awareness on the need for utilization and conservation of these resources is needed.

The Importance of African Savannah Ecosystem in the Evolution of The More Important Tropical Forage Genetic Resources

Cultivated pasture species come from two plant families: grasses (Family Poaceae) and legumes (Family Fabaceae). A few other minor sources of cultivated fodder species come from heterogeneous families: the fodder brassicas (Family Crucifereae); saltbush (Family Amaranthaceae, Subfamily Chenopodioideae); fodder beet (Chenopodiaceae); and willow tree (Salicaceae).

The grass family, Poaceae (Gramineae) consists of five subfamilies, namely, Bambusoideae, Arundinoideae, Panicoideae, Chloridoideae, and Pooideae. The top 45 important tropical forage grasses now in cultivation throughout the world have their climatic origin in tropical savannah and are predominantly African in distribution where there is high diversity of grass species with high level of endemism and a high wealth of animals in the largest grass-herbivore
ecosystems (e.g. the Greater Serengeti savannah grassland of East Africa). About half of the species occurring in Africa are distributed in the Sudano-Zambezian region. Most belong to subfamily Panicoideae or Chloridoideae.

The legume family, Fabaceae (Leguminosae) with its 17,000 species is the third largest plant family next to the Compositeae and Orchidaceae. It has three subfamilies, the Caesalpinioideae, Mimosoideae and Papilionoideae. Except for 3 genera the whole Caesalpinioideae subfamily is woody. Some 10 species of the genera deserve evaluation mostly as browse. The more promising genera include Cassia, Bauhinia, Cordeauxia and Hoffmannseggia. Africa with its 21 endemic genera is the center of diversity of the Casalpinioideae. All genera of the subfamily Mimosoideae are tropical in their distribution and almost all are armed. Alkaloids and other toxic compounds including non-protein amino acids are common in the sub family.

There are 33 tribes in the Papilionoideae of which 13 are from temperate climates and the rest 20 tribes from tropical areas. There are 345 genera in the tropics and 120 genera are temperate ones. The tropical forage legume resources are contained in 11 tropical tribes that comprise 620 species in 280 genera. Three major tribes contain the majority of non-toxic herbaceous tropical annual and perennial legume forages. The tribes are: Aeschynomenae, Desmodieae, and Phaseoleae. There are 8 other tribes that contain some potential forage genera but contain anti-nutritional compounds like gums, phenolic compounds, alkaloids.

Forage Genetic Resources and their Centers of Diversity in Ethiopia

Three of the major floristic regions of Ethiopia are important centers of genetic diversity: the Afroalpine and Afromontane; the Sudanian, and the Somali-Masai floristic regions.

The Afroalpine and Afromontane floristic region
The Afromontane region is very diverse in soil and physiography. Most of the floristic islands are formed of basalt rocks. The major highlands of Ethiopia cover an area totalling 490,000 km² or 43% of the total area of Africa. The highland mass is separated by the Great East African Rift Valley into the North-western and the South-eastern highlands.

The climate varies with altitude belts. In the forest belt, mean annual rainfall is more than 1000 mm. Above the forest belt, precipitation diminishes and in the Afroalpine belt appears to be much less than 1000 mm per year. The incidence of frost varies considerably from complete absence on some lower slopes to a
nightly occurrence on the highest summits. There are at least 4000 species of which about 3000 are endemic or near-endemic to the region. The main vegetation types include Afromontane forest, Afromontane bamboo, Afromontane bushland, and thicket, and Afromontane and Afroalpine grassland. The latter is of interest as a source of forage genetic resources.

The Afroalpine and Afromontane grasslands are climax and biotic type respectively, maintained by two factors: cold temperature in the alpine meadow; biotic factors (man’s destructive activity) in the montane grasslands. This balance of plant composition in favour of herbaceous communities plays an important role in dominance of important forage plant species (Table 1). Most of the species which dominate secondary grasslands in and above the Ericaceous and Afroalpine belts belong to the tribes Festuceae, Aveneae, and Agrostaeae, are Afromontane / Afroalpine endemics. While in the lower altitude forest belt, the secondary grassland is dominated by Andropogonoeae and Paniceae and the Trifoleae among the legume herb tribes.

About 35 – 40 *Trifolium* species have been recorded in Eastern Africa (Kahurananga J. and Mengistu, S., 1983; 1984). Ethiopia is considered as the secondary center of origin of the genus *Trifolium* (Zohary, 1972). Its huge highland mass is home to 28 *Trifolium* species (9 of them endemic) out of a total of 40 found in Eastern Africa (Kahurananga, J and Solomon Mengistu, 1983; 1984) (Table 2).

### Table 1. Distribution of the more important forage grass and legume species in the Afromontane and Afralpine regions in Ethiopia

<table>
<thead>
<tr>
<th>Herbaceous Legumes</th>
<th>Perennial Grasses</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Medicago polymorpha</em></td>
<td><em>Setaria sphaceleta</em></td>
</tr>
<tr>
<td><em>Medicago lupulina</em></td>
<td><em>Setaria chevalieri</em></td>
</tr>
<tr>
<td><em>Lotus shoeleri</em></td>
<td><em>Pennisetum clandestinum</em></td>
</tr>
<tr>
<td><em>Lotus</em></td>
<td><em>Andropogon distachys</em></td>
</tr>
<tr>
<td><em>Scorpurus muricatus</em></td>
<td><em>Pennisetum reparium</em></td>
</tr>
<tr>
<td><em>Argyrolobium rupestri</em></td>
<td><em>Annual grass</em></td>
</tr>
<tr>
<td>Tree/Shrub legume</td>
<td><em>Avena abyssinica</em></td>
</tr>
<tr>
<td><em>Sesbania sesban</em></td>
<td></td>
</tr>
<tr>
<td><em>Aeschynomene abyssinica</em></td>
<td></td>
</tr>
<tr>
<td><em>Erythrina brucei</em></td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Distribution and diversity of *Trifolium* in Ethiopia

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dega Damot (Agewmidir);</td>
<td><em>T. quartinianum</em>; <em>T. simense</em>; <em>T. decorum</em>; <em>T. billinatum</em>,</td>
</tr>
<tr>
<td></td>
<td><em>T. burchellianum</em>; <em>T. rueppellianum</em>; <em>T. usambarense</em>,</td>
</tr>
<tr>
<td></td>
<td><em>T. pichisermole</em>, <em>T. semipilosum</em>; <em>T. mattirolianum</em>; <em>T. Polystachyon</em></td>
</tr>
<tr>
<td>Dejen-Gozamin plateau/</td>
<td></td>
</tr>
<tr>
<td>Mount Choke and Mount Arat MekeraKir:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>N. Gondar: Debark, Gaynt and Estie</td>
<td><em>T. campestri</em>, <em>T. arvense</em>; <em>T. mattirolianum</em>, <em>T. Decorum</em></td>
</tr>
<tr>
<td>Wollo, Kutaber</td>
<td><em>T. polystachium</em></td>
</tr>
<tr>
<td>Arsi-Bale Highlands; Mount Chilalo (3500 m),</td>
<td><em>T. burchellianum</em> var Johnstonii and var oblongum*; <em>T. semipilosum</em></td>
</tr>
<tr>
<td>Dinsho Massif (4000 m),</td>
<td>var bruneli, <em>T. Usambarense</em>, <em>T. Simense</em></td>
</tr>
<tr>
<td>Sidama Highlands, Amaro Mountain massif, (Mount</td>
<td><em>T. burchellianum</em> var oblongum, <em>T. Usambarense</em></td>
</tr>
<tr>
<td>Dello, 4000 m)</td>
<td></td>
</tr>
<tr>
<td>Kibre Mengist plateau</td>
<td><em>T. somalense</em>, <em>T. Semipilosum</em></td>
</tr>
<tr>
<td>Eastern Wollega Highlands; Arjo, Horo Gudru;</td>
<td><em>T. billiniatum</em>, <em>T. usambarense</em>, <em>T. burchellianum</em>, <em>T. Rueppellianum</em></td>
</tr>
<tr>
<td>Shamboo</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Kahurananga, J and Solomon Mengistu, 1983; 1984*

**Threats to the Survival of Forage and Wild Plant Genetic Resources**

Human and livestock population has increased at a dramatic rate over the past few decades especially in developing countries. The two-fold increase in human population over the past two to three decades implies that more land has to be cultivated to meet the additional food requirements because the deficit cannot be balanced through increasing productivity owing to the negligible use of agricultural technology. The prehistoric oxen plough is still used in Ethiopia and about fifty million cattle are kept in a free-ranging grazing system, aggravating ecological degradation. New areas of forest and grazing lands, including steep slopes and waterlogged bottomlands, are being reclaimed for crop production, thus threatening the last refuge of forage and wild plant genetic resources.

Habitats of other species in the highlands are further endangered due to abandoning traditional land management and cropping systems. Traditional fallowing practices to replenish the fertility of continually cropped lands have been replaced by continual crop production, with a growing use of chemical fertilizers. In the central Ethiopian highlands, annual forage legumes from the
genera *Trifolium, Medicago, Lotus, Argyrolobium* and *Scorpusurus* grew in natural pastures used for rotation with arable crops for three to five years to restore soil fertility. Farmers recognized the clover and medic species as ‘useful weeds’ because land quickly restored its fertility (by fixing nitrogen). In addition livestock grazing on the fallow recycled nutrients through depositing manure. This system was favourable for these species, which grew vigorously and left an adequate amount of seed in the soil seed bank to perpetuate themselves over the cropping cycles. With the irreversible shift to continual cropping system, these valuable genetic resources are under threat of erosion.

Another threat to forage diversity occurs when land that could be a repository for rare and endemic plant species is allocated to public services like recreation, community forest, irrigated commercial farms, industry, settlement, mining or stone quarry. In cases where the public or local government are unaware about the importance to conserve biodiversity, the outcome can be genetic erosion and loss of biodiversity.

Changes in climate, including drought and extremes of temperature, have become a major threat to livelihoods and environment. This results in reductions in crop yield or even crop failure, loss of biodiversity and increased spread of diseases and parasites of plants and animals in developing nations, which have poor adaptive capacity. In addition, improper use of biophysical resources aggravates environmental degradation, inflicting irreversible damage to the watershed, arable land, and biodiversity leading to chronic food insecurity and at worst, widespread famine. Technologies are available to optimize agricultural productivity and mitigate and adapt to climate change.

**Concluding remarks and recommendations**

With the growing population of humans and livestock and severity of climate change, forage and wild plant genetic resources are under threats of erosion. Some measures that could be taken by concerned bodies to reduce the threat of erosion include:

- Identify and delineate gene centers and use GIS mapping techniques to facilitate monitoring of ecological status;
- Undertake *ex situ* conservation measures, including, collection, evaluation, variety development and establishment of botanic gardens;
- Undertake *in-situ* conservation of the more important habitats with high floristic diversity, and where necessary, reintroduce lost species back to their habitat; and
- Create public awareness to halt further undue degradation of vegetation
References


Forage Genetic Resources Conservation in Ethiopia

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Introduction

Ethiopia has a great diversity of forage grasses, forage legumes and browse species, which are indigenous. These plant genetic resources are the primary sources of animal feed. The indigenous forage gene pool has the potential to be used for improvement of livestock feed (Getahun Mulat, 2004). However, serious genetic erosion is taking place due to both natural and human factors. Very limited attention has been given in the past to the collection, conservation, characterization, and evaluation of the forage genetic resources for sustainable use in the national research programme.

The International Livestock Research Institute (ILRI) is the pioneer in Ethiopia for systematic exploration and collection of forage genetic resources, conservation and research. Accessions from different species of grass, forage legumes and browse species were collected from all ecological regions of Ethiopia. These activities were initiated in the Institute of Biodiversity and conservation (IBC) and since 1998; IBC has been conducting collection and conservation of forage genetic resources. Over the past decade, IBC has developed short and long-term conservation and assessed the status of forage genetic resources in Ethiopia. Although the impact of genetic erosion is clearly observed on the livelihoods of pastoralists and farmers, tangible and sustainable forage genetic resources conservation and sustainable use measures are far from alleviating the problem. This paper deals with experiences and future prospects of forage genetic resources conservation and sustainable use in Ethiopia.

Experiences and Status of Forage Genetic Resources Conservation

In-situ conservation of forage genetic resources

In-situ conservation is the conservation of the centres of natural variability where all the existing variations are maintained inherently unchanged. It involves the maintenance of genetic resources with due regard to the natural ecosystem, which allows continued evolution, and is dynamic by its nature. IBC
is not directly involved in the \textit{in-situ} conservation of forage genetic resources in Ethiopia. \textit{In-situ} conservation of forage genetic resources in Ethiopia includes:

\textbf{Farmer based \textit{in-situ} conservation:} In the central highlands of Ethiopia, farmers set aside lands between farmlands. They never allow free grazing in such areas and most of the time they use cut and carry system to feed the animals. They also harvest grasses from these areas for roofing. The forage plants growing in these areas serve as the local gene pool for forage genetic resources and crop wild relatives.

\textbf{Pastoral \textit{in-situ} conservation:} Traditional forms of pastoralism have maintained a dynamic equilibrium in a highly variable environment (Kakonge, 1995). The systems preserve natural ecosystems through extensive ranching and rational grazing management using cattle, goats, and sheep (Sindiga, 1994). These animals utilize different types and parts of the plant and grazing diversity is crucial for the sustainability of these traditional pastoral systems. According to Orskov and Viglizzo (1994), pastoral mobility in search of grazing and water is another principal strategy for overcoming drought and other environmental constraints. In semi arid zones unsuitable for farming, pastoralists conventionally ranged over large areas in order to take advantage of rainfall and vegetation resources that were variable in space and time (Kakonge, 1995). Pastoralists do not move horizontally across the plains, but vertically in seasonal migrations up and down the landscapes (Orskov and Viglizzo, 1994). Since landscapes have several plant communities with different kinds of species along the complex altitudinal gradient that is a combination of temperature, water and perhaps soil nutrient gradients, the greater vertical mobility of pastoralists allows grazing of different plant species in space and time and supports ecological regeneration. This will, therefore, significantly contribute to \textit{in situ} maintenance of forage genetic resources. Disruption of the pastoral way of life is leading to the loss of forage genetic resources. Invasion by both alien species and bush encroachment is also further aggravating the problem.

\textbf{National parks as \textit{in-situ} conservation areas:} National parks of Ethiopia account for 19 \% of the total area of the country. Records on conservation efforts in Ethiopia date back to the days of Emperor Zera-Yakob (1434-1468) who brought juniper seedlings from Wof Washa of North Shewa and planted them in the Managesha Suba area. This period falls in the customary conservation era, where for thousands of years Emperor Minilik began communities protected biodiversity by customary laws and modern conservation in 1908. This conservation initiative eventually evolved into the formulation of protected areas/National Parks in the 1960s. Many Ethiopian National Parks were established by removing people and it was the time where conservation by exclusion started in Ethiopia. This is conservation by Centralized Government Institutions using scientific knowledge and excluding local communities. The
conservation in the Ethiopian National Parks is still exclusionary and oriented to conserve game animals, especially grazers. As the forage plants are protected for wild animals, the national parks serve as one of the in-situ conservation areas for forage genetic resources. However, these areas are currently facing severe grazing conflicts, especially during the dry season, with the local communities.

**Ranches as in-situ conservation areas:** A ranch is an area of land that is used specifically for the practice of raising grazing livestock. While the main purpose is to raise livestock, government ranches can also be used for the conservation of domestic animal genetic resources and allow protection of forage genetic resources. Currently, privatization and conversion of government ranches into agricultural fields, for example in Metekel/Chagni, is a threat to forage genetic resources and once well protected forage genetic resources have been totally lost from this site.

**Area closure and cut and carry systems as in-situ conservation areas:** Area closure and controlled grazing can be used for revival of forage genetic resources threatened by over grazing, but complete exclusion of domestic animals might lead to loss of forage species. Some forage plants are palatable at all life stages. At the initial phase of area closure, the palatable plants will become more dominant with the absence of grazers. At a later stage of the area closure, however, non-palatable plants will become dominant and compete with palatable plants. This may lead to loss of important forage genetic resources unless the interaction of grazers is allowed to some degree.

**Ex-situ conservation of forage Genetic Resources**

*Ex-situ* conservation is where the seeds or the plant parts are preserved outside their area of growth or habitat. The option to conserve in seed storage depends on the seed characteristics, their ability to withstand desiccation and their longevity. Orthodox seeds (non-sensitive to moisture reduction) are conserved in the gene bank in cold room storage and species with recalcitrant seeds (sensitive to moisture reduction) are planted in the field gene bank.

**Gene bank/cold room storage:** The *ex-situ* conservation in the gene bank using cold storage facilities for orthodox seeds has been in practice in IBC for the past 35 years. The gene bank comprises one new room maintained at -20 °C for wild plants, three rooms maintained at -10 °C for cultivated plants and one room maintained at +4 °C for temporary storage and provides a total storage volume of 385 m³. Over 67,000 accessions of about 350 plant species have been conserved to date. The samples were mainly collected from different parts of Ethiopia and there are also a few donations. Among these, 688 accessions of forage genetic resources belonging to 142 plant species are conserved in the IBC gene bank.
The field gene bank: Field gene banks are one of the techniques used for plant genetic conservation. It is an *ex-situ* method where genetically diverse plants are maintained away from their original location and samples are conserved as living collections. The field genebank is the most common method of conserving plant genetic resources of species with recalcitrant seed and vegetatively propagated plants.

As part of the *ex-situ* conservation plan of IBC, a forage field gene bank was established at Wendo Genet in half a hectare area in 2004. The site is located around 264 km south of Addis Ababa at 07° 05.25' N and 38° 38.04' E. The field gene bank is found in the moist weina dega, agro-ecological zone of Ethiopia. The soil type is fertile black forest soil and the altitude is around 1830 meters above sea level. Although the site was originally designed as a field gene bank for vegetatively propagated forage and pasture plants, especially for grass species, it is also used for forage seed multiplication and characterization.

Challenges in Conservation of Forage Genetic Resources

In relation to *in-situ* conservation of forage genetic recourses, the major challenges in the pastoral areas include the risk of invasion and dominance of invasive alien species, the highly variable environment and recurrent drought in the lowland areas of Ethiopia. In the highland areas, agricultural expansion and reduction in land holdings lead to loss of forage genetic resources that used to be maintained *in-situ* by farmers.

Staff instability, lack of taxonomic knowledge, difficulty in identification of the true seed of forage plants are among the frontline challenges faced in IBC in executing *ex-situ* conservation of forage genetic resources. In addition to these, the majority of forage species are wild and produce few or no seed or shatter before harvesting. Thus, they require intensive management and require higher resources compared to domesticated plants.

Opportunities for Conservation of Forage Genetic Resources

Ethiopia has several opportunities to improve its activities in conservation and use of forage genetic resources. There are no policy bottlenecks in biodiversity conservation because Ethiopia has developed a biodiversity conservation policy, established various laws and regulations, designated the implementing institution and developed a national biodiversity conservation strategy and action plan for better conservation and sustainable use of its biological resources and associated indigenous knowledge.
Currently IBC have enough space in their gene bank/cold room and sufficient laboratory facilities for conservation of forage genetic resources. The skill and knowledge of handling difficult seeds are also acquired through training of some staff in collaboration with the Millennium Seed Bank Project of Kew, United Kingdom.

The taxonomic knowledge accumulated in the flora project during preparation of the flora of Ethiopia and Eritrea by the National Herbarium of the Addis Ababa University is an excellent opportunity for botanical identification of forage plants. Plant identification will help in distinguishing exotic plants (mainly alien plant species and useful or economically important exotic plants), indigenous plants and endemic plants that are used as forage plants. This will hopefully clarify taxonomic problems in the conservation and sustainable use of forage genetic resources in Ethiopia.

**Conclusion**

The issues discussed in this paper shows that the forage genetic resources conservation and sustainable use in Ethiopia is at an infant stage. Exploration, collection, characterization and use of forage genetic resources should be incorporated in the development agenda of the country. It is timely to utilize the existing opportunities and resolve issues described as challenges and embark on conservation and sustainable use of forage genetic resources of Ethiopia.

**References**


Introduction

Poor-quality feed and fluctuating feed supplies are major constraints to increased livestock productivity in many tropical countries. The inability of producers to feed animals adequately throughout the year is the most widespread technical constraint to improving productivity. Poor nutrition can result from lack of feed and/or low nutritive value of the feeds available. The relative importance of these constraints varies across agro-ecological zones.

Forage legumes can provide a high-quality dietary source for improving livestock feed. Forage production is limited in many countries by lack of knowledge on the benefits of forages or their management and lack of locally available seeds for farmers. Uncertain demand, with an associated high degree of risk to seed producers, has been considered as the major reason for poor investment in forage seed supply in many developing countries (Ferguson and Loch, 1999). In Ethiopia, there are some formal but still insufficient forage seed supply systems in government research institutions, farmer and community seed supply systems and more recently some involvement of private seed producers to meet the growing demand.

Understanding and managing forage diversity is essential for developing new forage resources to alleviate these constrains. The knowledge generated from the forage diversity work allows scientists to identify genotypes that have higher potential as livestock feeds.

Forage Activities at International Livestock Research Institute (ILRI)

Forage diversity conservation
The forage germplasm collection was created by International Livestock Center for Africa (ILCA), in 1983. The ILRI Gene bank conserves nearly 19,000 accessions of forages from over 1000 species belonging to over 200 genera.
Materials were collected between 1983 and 1993 and many other materials were donated to the collection. The majority of the collection is from Sub-Saharan Africa with 17% collected in Ethiopia. This is one of the most diverse collections of forage grasses, legumes and fodder tree species held in any gene bank in the world and includes the world’s major collection of African grasses and tropical highland forages.

In October 2006, ILRI signed an agreement to include this material under the International Treaty on Plant Genetic Resources for Food and Agriculture. It claims no ownership nor seeks any intellectual property rights over the germplasm and related information. To ensure continued free availability of this germplasm, ILRI distributes all material with a Standard material Transfer Agreement and requires recipients of its germplasm to accept the same conditions.

Forage genetic resources activities at ILRI are part of a System-wide Genetic Resources Program (SGRP) of the Consultative Group on International Agricultural Research (CGIAR). ILRI’s activity in forage genetic resources also supports the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture, which contributes to achieving the objectives of the Convention on Biological Diversity and Agenda 21 for sustainable development. It is also in line with the Millennium Development Goals for environmental sustainability.

ILRI aims to maintain a securely conserved diverse forage collection with related information and make them available as part of a rational global system of genetic resources conservation and sustainable use.

*Conservation* - Seeds are stored at low seed moisture contents in laminated aluminum foil packets in:

- Active genebank (at 8°C) for medium-term storage, research and distribution of seeds.
- Base genebank (at -20°C) for long-term storage.
- ILRI maintains a field genebank for grasses that rarely produce seeds or whose seeds are short-lived. The field gene banks are located at Zeway and Debre Zeit.

*Quality:* ILRI ensures quality of the seeds in the collection through monitoring viability and germplasm health.

*Regeneration:* Germplasm is multiplied for the genebank at four sites in Ethiopia. Temperate materials are grown at an altitude of 2350 m under rain fed conditions (Shola). Tropical and sub-tropical materials are multiplied at three locations under irrigation (soil pH 7 and 1950 m altitude – Debre Zeit; soil pH 8
and 1650 m altitude – Zeway) and under rain-fed (soil pH 4.5 and 1850 m altitude - Wolayita Soddo) conditions.

**Forage diversity use**

In addition to providing feeds, forages have a key role in enhancing natural assets through positive effects on soil fertility, increasing ground cover with associated benefits (biodiversity, carbon sequestration) for improving system resilience. They are an important land use strategy for marginal lands and steep slopes that are not suitable for crop production.

The major focus of ILRI’s research is to characterize the forage resources for use as livestock feeds (Table 1). This involves assessing variation in phenotype and nutritional traits, as well as resistance to diseases and pests. Genetic diversity is also studied using molecular techniques. Information generated from this research is used to identify superior accessions or best bets for further agronomic evaluation and utilization as part of sustainable farming systems.

**Table 1. Sets of germplasm characterized by ILRI**

<table>
<thead>
<tr>
<th>Species</th>
<th>Mrph</th>
<th>Molec</th>
<th>Prdct</th>
<th>Feed quality</th>
<th>Drought</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia angustissima</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>Odenyo et al., 2003 and Reed et al., 2001</td>
</tr>
<tr>
<td>Buffel grass</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Jorge et al., 2008</td>
</tr>
<tr>
<td>Couch grass</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Van de Wouw et al., 2008a</td>
</tr>
<tr>
<td>Cowpea</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
<td>√</td>
<td>Koralagama et al., 2008</td>
</tr>
<tr>
<td>Desmanthus species</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Basweti (unpublished)</td>
</tr>
<tr>
<td>Grass pea</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td>Tsegaye, 2007 (MSc thesis) and Wu et al., 2008</td>
</tr>
<tr>
<td>Guinea grass</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Van de Wouw et al., 2008b</td>
</tr>
<tr>
<td>Lablab</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td>Pengelly and Maass, 2001 and Maass et al., 2005</td>
</tr>
<tr>
<td>Napier grass</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
<td>Lowe et al., 2003 and van de Wouw et al., 1999</td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
<td>Unpublished</td>
</tr>
<tr>
<td>Chloris species</td>
<td>√</td>
<td></td>
<td>√</td>
<td></td>
<td>√</td>
<td>Mnene et al., 2005 and Ponsens et al., 2010</td>
</tr>
<tr>
<td>Sesbania</td>
<td>√</td>
<td></td>
<td>√</td>
<td></td>
<td></td>
<td>Heering et al., 1996a, 1996b, 1996c, Jamnadass et al., 2005 and Plumb et al., 1996</td>
</tr>
<tr>
<td>Stylosanthes fruticosa</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hakiza et al., 1988a</td>
</tr>
<tr>
<td>Trifolium quartinianum</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Kahanrananga and Tsehay, 1991; Basweti and Hanson, 2010</td>
</tr>
<tr>
<td>Trifolium steudneri</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ayalew, 2002 (MSc thesis)</td>
</tr>
<tr>
<td>Zornia species</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hakiza et al., 1988b</td>
</tr>
</tbody>
</table>

*Mrph = Morphology; Molec = Molecular; Prdct = Productivity
ILRI is working with a broad range of development partners (Box 1) and farmers on participatory forage selection to better understand how farmer’s value and select forages as part of crop-livestock systems. Accessions of Napier grass (Hanson and Tedla, 2010), the fodder tree Sesbania (Mekoya, 2008) and Calliandra (Franzel et al., 2004) have already been widely adopted by farmers in the highlands of sub-Saharan Africa, especially as part of smallholder dairy systems. A list of the most popular types distributed in the last decades is given in Table 2.

<table>
<thead>
<tr>
<th>Box 1. Partners in forage use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)</strong></td>
</tr>
<tr>
<td>- Supporting forage seed production in countries through capacity development</td>
</tr>
<tr>
<td><strong>European Association of Directory Publishers (EADP)</strong></td>
</tr>
<tr>
<td>- Studying feeding systems, feed scarcity and promoting forage based feeding strategies for dairy</td>
</tr>
<tr>
<td>- Introducing forages in pilot sites</td>
</tr>
<tr>
<td><strong>International Fund for Agricultural Development (IFAD): fodder adoption project</strong></td>
</tr>
<tr>
<td>- Doing action research to stimulate the innovation system and a more coordinated multi-actor approach to forage development</td>
</tr>
<tr>
<td>- Fodder round table</td>
</tr>
<tr>
<td>- Local learning alliances</td>
</tr>
<tr>
<td><strong>Ministry of Agriculture (MoA), Ethiopia</strong></td>
</tr>
<tr>
<td>- Promoting forage development in Ethiopia</td>
</tr>
<tr>
<td><strong>Ethiopian Meat and Dairy Technology Institute (EMDTI)</strong></td>
</tr>
<tr>
<td>- Supporting commercial meat and milk production in Ethiopia</td>
</tr>
<tr>
<td><strong>Ethiopian Institute of Agricultural Research (EIAR)</strong></td>
</tr>
<tr>
<td>- Evaluating and testing diverse materials on several agro ecologic regions</td>
</tr>
<tr>
<td><strong>Improving Productivity and Market Success of Ethiopian Farmers (IPMS)</strong></td>
</tr>
<tr>
<td>- Promoting forage based feeding strategies for meat and milk</td>
</tr>
<tr>
<td>- Introducing forages in PLWs</td>
</tr>
<tr>
<td>- Supporting small-scale seed marketing</td>
</tr>
<tr>
<td><strong>Non-Governmental Organizations (NGO’s)</strong></td>
</tr>
<tr>
<td>- Promoting forage development in Ethiopia</td>
</tr>
<tr>
<td><strong>Forage diversity project</strong></td>
</tr>
<tr>
<td>- Providing seeds and developing national capacity in seed production</td>
</tr>
<tr>
<td>- Developing new partnerships</td>
</tr>
<tr>
<td>- Introducing new forages</td>
</tr>
</tbody>
</table>
Services

Germplasm supply: ILRI provides small experimental quantities (between 1-20g) without charge from the germplasm collection under the terms of the standard material transfer agreement (SMTA) under the international treaty on plant genetic resources for food and agriculture as part of its policy of maximizing the utilization of material for research, breeding and training. The material is held in trust and the recipient has no rights to obtain Intellectual Property Rights (IPRs) on the material or related information. The recipient may utilize and conserve the material for research, breeding and training and may distribute it to other parties provided such other parties accept the terms and conditions of the SMTA. Every year, ILRI freely distributes more than 1,000 samples of germplasm globally for evaluation and further development and use by smallholder farmers.

Table 2. Popular seed unit materials distributed (1990-2010)

<table>
<thead>
<tr>
<th>Genera</th>
<th>Seeds distributed</th>
<th>Number of requests</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Stylosanthes</em></td>
<td>994</td>
<td>709</td>
</tr>
<tr>
<td><em>Desmodium</em></td>
<td>694</td>
<td>558</td>
</tr>
<tr>
<td><em>Medicago</em></td>
<td>427</td>
<td>553</td>
</tr>
<tr>
<td><em>Vicia</em></td>
<td>6952</td>
<td>513</td>
</tr>
<tr>
<td><em>Lablab</em></td>
<td>6728</td>
<td>486</td>
</tr>
<tr>
<td><em>Trifolium</em></td>
<td>827</td>
<td>460</td>
</tr>
<tr>
<td><em>Chloris</em></td>
<td>566</td>
<td>382</td>
</tr>
<tr>
<td><em>Macroptilum</em></td>
<td>435</td>
<td>358</td>
</tr>
<tr>
<td><em>Vigna</em></td>
<td>3180</td>
<td>338</td>
</tr>
<tr>
<td><em>Leucaena</em></td>
<td>778</td>
<td>276</td>
</tr>
<tr>
<td><em>Sesbania</em></td>
<td>1174</td>
<td>257</td>
</tr>
<tr>
<td><em>Panicum</em></td>
<td>148</td>
<td>251</td>
</tr>
<tr>
<td><em>Macrotyloma</em></td>
<td>515</td>
<td>248</td>
</tr>
<tr>
<td><em>Neonotonia</em></td>
<td>276</td>
<td>225</td>
</tr>
<tr>
<td><em>Cajanus</em></td>
<td>1146</td>
<td>223</td>
</tr>
<tr>
<td><em>Avena</em></td>
<td>8898</td>
<td>179</td>
</tr>
<tr>
<td><em>Setaria</em></td>
<td>95</td>
<td>149</td>
</tr>
<tr>
<td><em>Chamaecrista</em></td>
<td>142</td>
<td>135</td>
</tr>
<tr>
<td><em>Centrosema</em></td>
<td>114</td>
<td>124</td>
</tr>
<tr>
<td><em>Desmanthus</em></td>
<td>109</td>
<td>89</td>
</tr>
<tr>
<td><em>Brachiaria</em></td>
<td>38</td>
<td>64</td>
</tr>
<tr>
<td><em>Cenchrus</em></td>
<td>22</td>
<td>44</td>
</tr>
<tr>
<td><em>Melilotus</em></td>
<td>116</td>
<td>41</td>
</tr>
<tr>
<td><em>Average</em></td>
<td>1495</td>
<td>290</td>
</tr>
<tr>
<td><em>Pennisetum</em></td>
<td>435621 (cuttings)</td>
<td>637</td>
</tr>
</tbody>
</table>
**Forage seed supply:** In 1989, ILRI recognized the constraint of forage seed supply to increased use of forages and established a forage seed production unit with funding from the Swiss Development Cooperation in response to the need to promote access to forage seeds to enhance the incorporation of forages into sustainable farming systems in sub-Saharan Africa. The role of the unit was to stimulate herbage seed production by providing starter seeds and training national partners in forage seed production. Requesters are asked to cover the costs of production and shipping to discourage them from relying on ILRI as a continuous source of seeds.

**Table 3. List of best bets for 2011**

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
<th>Scientific name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herbaceous legumes:</strong></td>
<td></td>
<td><strong>Grasses:</strong></td>
<td></td>
</tr>
<tr>
<td>Centrosema pascuorum</td>
<td>-</td>
<td>Avena sativa</td>
<td>Oats</td>
</tr>
<tr>
<td>Desmodium intortum</td>
<td>Greenleaf</td>
<td>Brachiaria decumbens</td>
<td>Signal grass</td>
</tr>
<tr>
<td>Desmodium uncinatum</td>
<td>Silverleaf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lablab purpureus</td>
<td>Lablab</td>
<td>Chloris gayana</td>
<td>Rhodes grass</td>
</tr>
<tr>
<td>Lupinus albus</td>
<td>Lupin</td>
<td>Pennisetum purpureum (500</td>
<td>Napier</td>
</tr>
<tr>
<td>Lupinus angustifolius</td>
<td>Lupin</td>
<td>Setaria sphacelata</td>
<td>Setaria</td>
</tr>
<tr>
<td>Medicago littoralis</td>
<td>Harbinger medic</td>
<td><strong>Fodder trees:</strong></td>
<td></td>
</tr>
<tr>
<td>Medicago sativa</td>
<td>Alfalfa</td>
<td>Cajanus cajan</td>
<td>Pigeon pea</td>
</tr>
<tr>
<td>Medicago truncatula</td>
<td>Barrel medic</td>
<td>Desmanthus virgatus</td>
<td>Desmanthus</td>
</tr>
<tr>
<td>Melilotus alba</td>
<td>Sweetclover</td>
<td>Leucaena leucocephala</td>
<td>Leucaena</td>
</tr>
<tr>
<td>Neonotonia wigtii</td>
<td>Glycine</td>
<td>Leucaena pallida</td>
<td>Highland</td>
</tr>
<tr>
<td>Stylosanthes hamata</td>
<td>Stylo</td>
<td>Sesbania sesban</td>
<td>Sesbania</td>
</tr>
<tr>
<td>Stylosanthes scabra</td>
<td>Stylo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trifolium decorum</td>
<td>Clover</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trifolium quartinianum</td>
<td>Clover</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trifolium steudneri</td>
<td>Clover</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicia benghalensis</td>
<td>Vetch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicia sativa</td>
<td>Vetch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicia villosa spp. dasycarpa</td>
<td>Vetch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicia villosa</td>
<td>Vetch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vigna unguiculata</td>
<td>Cowpea</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The seed production unit focuses on providing a source of tropical forage seeds and planting material of selected best-bet species for use in establishing national forage seed production, including 33 species of herbaceous legumes, 10 species of grass and 5 species of fodder trees. The list of the best bets for 2011 is detailed in Table 3 and the number of samples requested over the last decade is shown in Fig. 1.

![Figure 1. Number of samples requested from the seed unit over 20 years](image)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of requests filled</th>
<th>Number of samples distributed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>2000</td>
<td>20000</td>
</tr>
<tr>
<td>1991</td>
<td>1500</td>
<td>15000</td>
</tr>
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<td>1992</td>
<td>1100</td>
<td>11000</td>
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<td>1993</td>
<td>700</td>
<td>7000</td>
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<tr>
<td>1994</td>
<td>300</td>
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<td>1995</td>
<td>200</td>
<td>2000</td>
</tr>
<tr>
<td>1996</td>
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<td>1000</td>
</tr>
<tr>
<td>1997</td>
<td>50</td>
<td>500</td>
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<tr>
<td>1998</td>
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<td>200</td>
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<tr>
<td>1999</td>
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<td>100</td>
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<tr>
<td>2000</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>2001</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>2002</td>
<td>1</td>
<td>10</td>
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<tr>
<td>2003</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2004</td>
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<td>20</td>
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<td>2005</td>
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<td>100</td>
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<td>2006</td>
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<td>200</td>
</tr>
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<td>2007</td>
<td>30</td>
<td>300</td>
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<td>2008</td>
<td>40</td>
<td>400</td>
</tr>
<tr>
<td>2009</td>
<td>50</td>
<td>500</td>
</tr>
<tr>
<td>2010</td>
<td>60</td>
<td>600</td>
</tr>
</tbody>
</table>

**Figure 2a. Genebank versus seed unit distribution over 20 years – Total number of requests and samples, for Ethiopia and international users**

However, despite the high costs of seeds, ILRI has remained a major supplier of forage seeds in Ethiopia in the absence of alternative suppliers and has provided over 7000 samples in response to 1100 orders from 1990 to date throughout much of Ethiopia (Fig. 2a). These seeds have been distributed to government
offices and institutes, NGOs, educational institutions and private farmers and seed producers, providing starter seeds for forage production in the country.

In accordance with their roles, the genebank is mainly catering for international requests to supply a large varieties of accessions in small quantities to requesters while the Seed Unit is used to provide larger quantities of a fewer number of accessions mainly to requesters in Ethiopia (Fig 2a). The type of clientele also differs for the gene bank and Seed Unit with most of the samples from the gene bank being supplied to research organizations and most of the samples from the Seed Unit being supplied to the governmental and non-governmental development agencies (Fig 2b).

![Genebank versus seed unit distribution over 20 years – Category of users](image)

**Figure 2b. Genebank versus seed unit distribution over 20 years – Category of users**

Internal reports on demand for forage species as a methodology to calculate the approximate cost of production of forage seeds have been developed recently by student attachments at ILRI. Forage seed production tends to be a very labor intensive activity and the cost of labor for planting, weeding and seed harvesting was found to be the major cost component for forage seed production in ILRI (Fig 3.).

**Knowledge:** In order to promote use and adoption of forages ILRI, the CGIAR and national and international partners developed and compiled forage germplasm information and made it widely available to users. Several websites are available with information for different levels of users: ILRI has been involved in a project with the Commonwealth Scientific and Industrial Research Organization (CSIRO) and the Centro Internacional de Agricultura Tropical (CIAT) to develop an interactive information and selection tool for tropical
forages. http://www.tropicalforages.info/ international forages fact sheets and an interactive tool to select suitable forages types for specific environments

![Figure 3. Major components of seed production costs in Debre Zeit](From: Phanuel, 2008)

ILRI has also produced information sheets on some key forage species that were also translated into local languages in Ethiopia. http://mahider.ilri.org/handle/10568/658 See the pdf links on the right end side of the webpage, with links to fact sheets of recommended forage materials http://mahider.ilri.org/handle/10568/226/simple search?query=leaflet&rpp=30&sort_by=1&order=ASC link to forage fact sheets http://mahider.ilri.org/handle/10568/3014 link to participatory evaluation

Recently the team at ILRI has been involved in the development of a knowledge sharing platform for managing genebanks, the Crop Genebank Knowledge Base (CGKB). There are two major sections on forage legumes and forage grasses that include several references, manuals and interactive modules. http://cropgenebank.sgrp.cgiar.org/ web site about management of genebanks

Another CGIAR initiative created a database of all accessions available in the CGIAR genebanks, that includes an online ordering system. http://singer.cgiar.org/
There is also information about the forage activities at ILRI on the Forage Diversity website. http://www.ilri.org/ForageDiversity.

**Capacity building:** To strengthen the research capacity of institutions in developing countries, ILRI has been providing training for national and international - scientists, technicians and famers in germplasm management and seed production. More that 75% of the beneficiaries were from Ethiopia plus a wide range of other African, European, Asian and American countries, (Fig. 4).
Some training manuals have been produced in the past and some are available as hard copies, but most of them are available online (CGKB and Mahider).

**Discussion and Recommendations**

Work on forage seed production within ILRI supports users worldwide but is particularly focused on supporting sub-Saharan Africa. Despite the large numbers of samples of seeds distributed to the thousands of users from the forage gene bank and the herbage seed unit over the past decades, forage seed production remains relatively poorly developed in the region. International Centers do not have the comparative advantage nor the mandate or capacity to provide the quantities of seeds needed for national seed forage production. Seed production must be done by national, regional or local initiatives to meet farmer’s needs.

ILRI has recently re-evaluated its role in the supply of forage seeds and has been looking at options and opportunities for both the public and private sector to take over this task. ILRI strategy is for the herbage seed unit to continue to focus on capacity strengthening and provision of foundation seeds of new and promising forage types to the public and private sector. It also aims at contributing to research the processes and enabling environments that support development of forage seed systems, particularly in Ethiopia.
The way forward

In order to support the transition to public-private partnerships for forage seed supply ILRI is aiming at:

- Assessing the extent of adoption and impact of tropical forages as livestock feed.
  - Working with partners and farmers in systems at different levels of intensification using focus group discussions, key information interviews and household surveys.
- Facilitating public-private partnerships for forage seed production in Ethiopia.
  - Study constraints, opportunities and lessons for forage seed production
  - Participatory diagnosis on effectiveness of alternative seed production and distribution systems.
References


Heering, H., Reed, J.D. and Hanson, J. 1996a. Differences in *Sesbania sesban* accessions in relation to their phenolic concentration and HPLC fingerprints. Journal of the Science of Food and Agriculture, 71:92-98.


Forage Seed Production and Supply Systems in the Central Highlands of Ethiopia

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Introduction

Feed shortage and poor quality of available feed resources are the major constraints to increased livestock productivity in sub-Saharan Africa (HSU, 1994). Adequate supply of feed is crucial to livestock production that supports the livelihoods of millions of people across the developing world. Livestock producers meet their fodder requirements through a combination of crop residues, grazing on communal and private lands, forests, fallow lands, harvested croplands, and cultivated forage crops. Feeds/fodder market is growing but availability and access to quality feed resources remains to be a challenge in livestock production in Ethiopia. The current policy towards more production per unit number and/or area and increased improved breeds in central highlands of Ethiopia has also increased the demand for more and improved fodder.

Research has identified a range of adaptable and productive forage species that can be integrated into the local production systems for improving livestock productivity. However, the adoption of these forage species by livestock farmers is low. One reason for this may be the lack of a ready supply of good quality seed/planting material at affordable prices. One of the most pressing concerns related to seed supply of improved forage varieties is how to establish sustainable seed supply systems for commodities that cannot be economically supplied through a centralized, formal seed industry (CIAT, 2003).

The estimated doubling of demand for meat and milk in developing countries in the next two decades offers significant opportunities to poor livestock producers to increase their income from livestock farming (Delgado, et al., 1999). Availability of quality seed is critical to feed development and livestock productivity to meet the expanding meat and milk demand. In general, there is no clear cut strategy or system of forage seed production and supply in Ethiopia. Hence, it is important to understand the existing forage seed production and supply systems of Ethiopia in order to have a concerted effort to develop a
national strategy and improve seed availability. This study was aimed at assessing, analyzing, and generating information on the forage/fodder seed production and supply systems in central highlands of Ethiopia.

**Materials and methods**

**The study area**
The study was conducted in the mixed crop-livestock production system of North Shewa, West Shewa, and Arsi zones, where livestock production is an integral part of the system. Cereals (tef, wheat, and barley), highland pulses (peas, beans, lentils), and oil seeds (linseed, noug, brassica) are grown in these areas. Availability and contribution of crossbred cattle to the farming system is relatively better than other regions under smallholder farmers' condition. Districts were selected to represent the crop-livestock production system of the highlands.

**Selection of districts (Kebeles) and farmers**
The primary data for this study were collected in 2011 from farmers in the central highlands of Ethiopia, and were supplemented with secondary data from publications of International Livestock Research Institute (ILRI), private seed enterprise and non-governmental organizations (NGOs) involved in forage seed production and/or supply system in the country and from government. Data were also collected based on interviews with key informants: experts of the respective district office of agriculture, development agents (Das) and elders. Data generated through personal observations through field visits were also considered.

Ten districts from North Shewa (Wuchale, Girar Jarso and Degem), West Shewa (Ejere, Dendi, Jeldu, Ambo, Welmera and Robgebeya) and Arsi (Tiyo) zones were selected using purposive sampling technique. A single-visit formal survey method (ILCA, 1990) was used to collect information on forage seed supply systems in the districts. Twenty-three Kebeles (peasant associations) from the ten districts were chosen purposively from a cluster of areas growing improved forages. 30, 35, and 22 households (HHs) were selected from each districts (kebeles) in North Shewa, West Shewa and Arsi zones, respectively using systematic random sampling technique. A pre-tested structured questionnaire was used for data collection on HHs and forage seed supply system.

**Statistical Analysis**
Data were analyzed using Statistical Package for Social Sciences (SPSS statistics 17.0, year). Descriptive statistics such as mean, percentage, standard error of means, minimum and maximum were used to report the data.
Results and Discussion

Improved seed production and development
Introduction of improved forages has been facilitated through a number of projects like the Fourth National Livestock Development Project (FNLPD), the Smallholder Dairy Development Project (SDDP), and the National Livestock Development Project (NLDP) using government nurseries for multiplication and seed production. The central highlands of Ethiopia have been benefiting from the distribution of crossbred heifers (dairy stock distribution), co-operatives development, strengthening of artificial insemination (AI) services at field level and milk marketing and processing facilitated through these projects which resulted in increased sustainable smallholder dairy production (Ahmed et al., 2003). However, most of these projects failed to address genetic improvement and the feed shortage or nutritional problems simultaneously.

Recent trends indicated that there is a renewed interest to improved forages for feed production and natural resources management in Ethiopia. The total amount of forage seeds and cuttings sold to regional governments, NGOs and the private sector from ILRI’s forage seed unit in Addis Ababa, Ethiopia has increased from the year 2001 to 2005 by a factor of 3.5. Over the last five years, there was the highest demand for forage seeds including *Avena sativa* (1620 kg), *Lablab purpureus* (665 kg), *Vicia dasycarpa* (350 kg), *Trifolium quartinianum* (180 kg) and *Vigna unguiculata* (100 kg). Similarly, sales of Napier grass increased from 580 in 2000 to about 1.5 million cuttings in 2005. Apart from increasing trends in requests, data on the use of these materials and feedback about productivity under farm conditions and farmers perception are not available (Azage et al., 2010). Sesbania has been widely used in the smallholder sector as shown in surveys made in Ethiopia (Abebe et al. 2008). The five-year Improving Productivity and Market Success of Ethiopian Farmers Project (IPMS) funded by the Canadian International Development Agency (CIDA) and implemented by the ILRI on behalf of the Ethiopian Ministry of Agriculture (MoA) is also involved in seed supply systems in 10 Pilot Learning Woredas (PLWs) for developing a community based market oriented agricultural program across the country.

Recently a local private seed enterprise, Eden Field Agri-Seed Enterprise, is involving in forage and fodder tree seed production and supply activities with the focus of enhancing quality seed supply to farmers and other customers for different agro-ecologies of Ethiopia. In addition to seed production on their own farms, the enterprise also produce seeds on farmer’s field based on contractual agreements to buy their produce. However, the involvement of the private sector in forage seed production has been limited as the market at farmers level for these resources has not yet been developed (Azage et al., 2010).
NGOs such as Land O’Lakes and projects like Feed Enhancement for Ethiopian Development (FEED), which is a two-year project funded by the USDA implemented by ACDI/VOCA are also involved in seed supply systems. Seeds purchased from NARS (National Agricultural Research System), NGOs, commercial producers and farmers are being distributed to the unions and cooperatives. The cooperatives use some of the seeds for themselves and/or distribute to individual member farmers using a seed revolving mechanism. Forage seed supply mechanisms include free of charge, contractual and sale bases. The sustainability of these projects in developing a market-oriented livestock production system that responds to adoption of feeds and improved forage/fodder seed technologies is questionable due to the short life span of the projects.

**Landholding and land use patterns**
The average total land holding per HH of the three administrative zones ranges 2.72 to 3.93 ha with an overall average of 3.54 ha. Considering individual respondents, land holding per HH ranges 0.3 to 9.5 ha. On average 2.26, 0.73, 0.32 and 0.22 ha of the total land holding per HH is accounted for crop production, grazing area, homesteads and improved forages, respectively (Table 1). The result indicate that, in the study areas the farming system is crop dominated and land allocated for livestock agriculture is generally low.

**Improved forages/fodder production and seed sources**
The majority of the respondents (72.4%) cultivate improved forages/fodder species while the rest of the respondents (27.6%) were not practicing improved forages/fodder production (Table 2). Most of the respondents (86.4%) from Arsi and (82.9%) from West Shewa zones cultivate improved forage crops, while only 50% of the respondents of North Shewa do cultivate forage crops. The higher use of improved forage crops in Arsi and West Shewa zones resulted from better exposure and access to improved technologies may be as a result of the development projects and public institutions. Therefore, strong extension works need to be made in potential areas of the country to benefit smallholder livestock producers from forage production.

The herbaceous legumes such as vetch species and alfalfa; fodder grasses such as oats and napier grass and fodder trees such as tree lucerne and Sesbania species were cultivated by the majority of the respondents in all the studied areas while pasture grasses such as rye and rhodes grasses were cultivated only in Arsi zone by a small number of respondents. Fodder beet was cultivated both in the Arsi and North Shewa Zones but not in the West Shewa Zone.
Table 1. Household land holding (ha) and land use pattern in three administrative zones

<table>
<thead>
<tr>
<th>Zone</th>
<th>Homestead</th>
<th>Crop production</th>
<th>Improved forage</th>
<th>Gazing pasture</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsi (N=22)</td>
<td>Mean 0.27</td>
<td>1.36</td>
<td>0.18</td>
<td>0.81</td>
<td>2.72</td>
</tr>
<tr>
<td></td>
<td>SEM 0.04</td>
<td>0.22</td>
<td>0.05</td>
<td>0.27</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>Min-Max 0.04-0.75</td>
<td>0.0-3.5</td>
<td>0.0-1.0</td>
<td>0.0-5.6</td>
<td>0.3-6.5</td>
</tr>
<tr>
<td>West Shewa (N=35)</td>
<td>Mean 0.31</td>
<td>2.81</td>
<td>0.28</td>
<td>0.50</td>
<td>3.93</td>
</tr>
<tr>
<td></td>
<td>SEM 0.04</td>
<td>0.23</td>
<td>0.04</td>
<td>0.08</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>Min-Max 0.05-1.25</td>
<td>0.5-7.0</td>
<td>0.0-1.0</td>
<td>0.0-2.0</td>
<td>1.25-8.5</td>
</tr>
<tr>
<td>North Shewa (N=30)</td>
<td>Mean 0.37</td>
<td>2.29</td>
<td>0.18</td>
<td>0.94</td>
<td>3.69</td>
</tr>
<tr>
<td></td>
<td>SEM 0.06</td>
<td>0.28</td>
<td>0.05</td>
<td>0.20</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>Min-Max 0.01-1.25</td>
<td>0.25-5.75</td>
<td>0.0-1.0</td>
<td>0.0-5.0</td>
<td>0.57-9.5</td>
</tr>
<tr>
<td>Total (N=87)</td>
<td>Mean 0.32</td>
<td>2.26</td>
<td>0.22</td>
<td>0.73</td>
<td>3.54</td>
</tr>
<tr>
<td></td>
<td>SEM 0.03</td>
<td>0.16</td>
<td>0.03</td>
<td>0.10</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>Min-Max 0.01-1.25</td>
<td>0.0-7.0</td>
<td>0.0-1.0</td>
<td>0.0-5.6</td>
<td>0.3-9.5</td>
</tr>
</tbody>
</table>

SEM=standard error of the mean; N = number of respondents

Table 2. Percent of respondents that cultivated improved forages in the central highlands of Ethiopia

<table>
<thead>
<tr>
<th>Variables</th>
<th>Zone</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arsi (N=22)</td>
<td>West Shewa (N=35)</td>
</tr>
<tr>
<td>Improved forage</td>
<td>Yes 86.4</td>
<td>82.9</td>
</tr>
<tr>
<td>Establishment</td>
<td>No 13.6</td>
<td>17.1</td>
</tr>
</tbody>
</table>

N = number of respondents

The Ministry of Agriculture, research institutes, and NGOs are the major seed sources for smallholder framers. Farmers also obtained their seed from own saved seeds, small traders, open markets, and farmer groups. Forage seed production is not well developed and private sector involvement is very limited or non-existent in the study area.
Land allocated for improved forage species and number of planted fodder trees
Most of the respondents were cultivating fodder oats (*Avena sativa*) as a sole crop or as a mixture with vetch species, allocating a quarter of their land in West and North Shewa areas. Oats/vetch mixture is relatively more utilized in West than North Shewa zone due to interventions of research centers in West Shewa zone. In West Shewa zone, the mean number of fodder trees planted by the respondents per HH is 224 and ranged from 8 to 2000. This is higher than the number of fodder trees grown in Arsi and North Shewa zones. Tree lucerne is planted up to 2000 trees per HH at Jeldu district in West Shewa zone (Table 3).

Table 3. Household land allocation (ha) for pasture, different forage species and number of fodder trees established in three administrative zones of central Ethiopia

<table>
<thead>
<tr>
<th>Zone</th>
<th>Pasture grasses (ha)</th>
<th>Herbaceous legumes (ha)</th>
<th>Fodder grasses (ha)</th>
<th>Fodder trees (Number of plants)</th>
<th>Fodder beet (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsi (N=19)</td>
<td>Mean 0.05</td>
<td>0.04</td>
<td>0.12</td>
<td>98</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>SEM 0.05</td>
<td>0.02</td>
<td>0.01</td>
<td>25.78</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Minimum 0.00</td>
<td>0.00</td>
<td>0.04</td>
<td>10</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Maximum 0.10</td>
<td>0.13</td>
<td>0.20</td>
<td>300</td>
<td>0.01</td>
</tr>
<tr>
<td>West Shewa (N=29)</td>
<td>Mean 0.02</td>
<td>0.25</td>
<td>0.26</td>
<td>224</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>SEM 0.01</td>
<td>0.00</td>
<td>0.02</td>
<td>132.85</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Minimum 0.01</td>
<td>0.24</td>
<td>0.05</td>
<td>8</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Maximum 0.08</td>
<td>0.25</td>
<td>0.50</td>
<td>2000</td>
<td>-</td>
</tr>
<tr>
<td>North Shewa (N=15)</td>
<td>Mean 0.01</td>
<td>0.24</td>
<td>0.23</td>
<td>72</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>SEM -</td>
<td>0.01</td>
<td>0.05</td>
<td>24.38</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Minimum 0.01</td>
<td>0.20</td>
<td>0.01</td>
<td>2</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Maximum 0.01</td>
<td>0.25</td>
<td>0.50</td>
<td>250</td>
<td>0.15</td>
</tr>
<tr>
<td>Total N=63</td>
<td>Mean 0.03</td>
<td>0.20</td>
<td>0.21</td>
<td>142</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>SEM 0.01</td>
<td>0.02</td>
<td>0.02</td>
<td>55.54</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Minimum 0.00</td>
<td>0.00</td>
<td>0.01</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Maximum 0.10</td>
<td>0.25</td>
<td>0.50</td>
<td>2000</td>
<td>0.15</td>
</tr>
</tbody>
</table>

*SEM=standard error of mean; N = number of respondents*

Livestock holdings
Data on livestock holdings of the respondents by administrative zones are presented in Table 4. The average crossbred dairy cows having 50% and above exotic blood level holding per HH of 1.66 was greater than the average local dairy cows holding per HH of 1.06. This indicates the better availability of crossbred dairy cows in the central highlands of Ethiopia. Hence, promotion of
### Table 4. Livestock holdings (number of heads per household) in three administrative zones of central Ethiopia

<table>
<thead>
<tr>
<th>Zone</th>
<th>Goat</th>
<th>Sheep</th>
<th>Oxen/Beef</th>
<th>Donkey</th>
<th>Horse</th>
<th>Local dairy cows</th>
<th>Crossbred* dairy cows</th>
<th>Local replacement heifers/ calves</th>
<th>Crossbred* replacement heifers/ calves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsi (N=22)</td>
<td>Mean</td>
<td>0.64</td>
<td>4.77</td>
<td>0.68</td>
<td>1.77</td>
<td>0.86</td>
<td>0.23</td>
<td>1.73</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>SEM</td>
<td>0.35</td>
<td>1.27</td>
<td>0.23</td>
<td>0.26</td>
<td>0.26</td>
<td>0.11</td>
<td>0.42</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>% of Total N</td>
<td>25.3</td>
<td>25.3</td>
<td>25.3</td>
<td>25.3</td>
<td>25.3</td>
<td>25.3</td>
<td>25.3</td>
<td>25.3</td>
</tr>
<tr>
<td></td>
<td>Min-Max</td>
<td>0-7</td>
<td>0-20</td>
<td>0-3</td>
<td>0-5</td>
<td>0-4</td>
<td>0-2</td>
<td>0-10</td>
<td>0.5</td>
</tr>
<tr>
<td>West Shewa (N=35)</td>
<td>Mean</td>
<td>1.40</td>
<td>11.23</td>
<td>2.17</td>
<td>2.20</td>
<td>1.34</td>
<td>1.77</td>
<td>1.69</td>
<td>2.40</td>
</tr>
<tr>
<td></td>
<td>SEM</td>
<td>0.63</td>
<td>2.94</td>
<td>0.41</td>
<td>0.31</td>
<td>0.30</td>
<td>0.32</td>
<td>0.25</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>% of Total N</td>
<td>40.2</td>
<td>40.2</td>
<td>40.2</td>
<td>40.2</td>
<td>40.2</td>
<td>40.2</td>
<td>40.2</td>
<td>40.2</td>
</tr>
<tr>
<td></td>
<td>Min-Max</td>
<td>0-15</td>
<td>0-80</td>
<td>0-11</td>
<td>0-8</td>
<td>0-6</td>
<td>0-8</td>
<td>0-7</td>
<td>0-8</td>
</tr>
<tr>
<td>North Shewa (N=30)</td>
<td>Mean</td>
<td>0.00</td>
<td>9.93</td>
<td>1.43</td>
<td>1.47</td>
<td>0.30</td>
<td>0.83</td>
<td>1.57</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>SEM</td>
<td>0.00</td>
<td>1.24</td>
<td>0.23</td>
<td>0.22</td>
<td>0.10</td>
<td>0.19</td>
<td>0.32</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>% of Total N</td>
<td>34.5</td>
<td>34.5</td>
<td>34.5</td>
<td>34.5</td>
<td>34.5</td>
<td>34.5</td>
<td>34.5</td>
<td>34.5</td>
</tr>
<tr>
<td></td>
<td>Min-Max</td>
<td>0-0</td>
<td>0-25</td>
<td>0-4</td>
<td>0-5</td>
<td>0-2</td>
<td>0-3</td>
<td>0-6</td>
<td>0-4</td>
</tr>
<tr>
<td>Total (N=87)</td>
<td>Mean</td>
<td>0.72</td>
<td>9.15</td>
<td>1.54</td>
<td>1.84</td>
<td>0.86</td>
<td>1.06</td>
<td>1.66</td>
<td>1.32</td>
</tr>
<tr>
<td></td>
<td>SEM</td>
<td>0.28</td>
<td>1.32</td>
<td>0.20</td>
<td>0.16</td>
<td>0.15</td>
<td>0.16</td>
<td>0.18</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>% of Total N</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Min-Max</td>
<td>0-15</td>
<td>0-80</td>
<td>0-11</td>
<td>0-8</td>
<td>0-6</td>
<td>0-8</td>
<td>0-10</td>
<td>0-8</td>
</tr>
</tbody>
</table>

*Crossbred- includes 50% and above (high-grade) exotic blood levels; SEM = standard error of mean; N = number of respondents
improved feed technologies in these areas has paramount importance to sustain smallholder dairy production.

**Seed purchase during the last five years**

Seed purchase was more practiced (57.9%) in Arsi zone than West and North Shewa zones (Table 5). However, the overall mean indicated that the majority of the respondents (63.5%) did not purchase forage/fodder seeds or planting materials. The reasons for not purchasing forage/fodder seeds are unavailability of seeds, lack of information, high cost of seeds, limitation of land and preference of their own seeds in their order of importance.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Zone</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arsi</td>
<td>West Shewa</td>
</tr>
<tr>
<td>Seed purchase during the last 5 years</td>
<td>N=19</td>
<td>N=29</td>
</tr>
<tr>
<td>Yes</td>
<td>57.9</td>
<td>24.1</td>
</tr>
<tr>
<td>No</td>
<td>42.1</td>
<td>75.9</td>
</tr>
</tbody>
</table>

\(N = \text{number of respondents}\)

Seed requirements of farmers is mainly met from their own saved seeds, relatives, friends and neighbors and is limited to a few forage species such as alfalfa (\textit{Medicago sativa}), fodder oats (\textit{Avena sativa}), \textit{Vicia} species (\textit{Vicia dasycarpa, Vicia villosa, Vicia sativa}), Napier grass, fodder trees (Tree Lucerne and Sesbania) and fodder beet (Table 6). Respondents purchased about 0.22 kg of alfalfa per HH at a cost of 200 birr per kilogram. The mean prices per kg of vetch was 9.42 birr ranging from 4.0 - 22.50 birr and that for oats seed was 3.41 birr with a range of 1.50 - 5.0 birr. The overall mean price of Napier grass per cutting and fodder tree per seedling purchased by the respondents were 0.5 and 0.8 Birr, respectively. The overall mean price for fodder beet was 87.50 Birr per kg ranging from 70 – 100 Birr per kg.

Sources of information on forage seed for most of the respondents were public extension (MoA) and research institutions followed by NGOs and friends (farmers). The type of information obtained by most of the respondents (95.2%) covered land preparation, planting, weeding, use of fertilizer, forage harvesting, and use of new forage species. Most farmers lack experience on forage seed production and management techniques. The characteristics of forage species including high yield, palatability, ease of harvest, drought tolerance, and fast growth were preferred by most of the respondents for selecting a particular forage species/variety across all studied areas. According to most of the respondents, forage seed availability is decreasing (44.4%) while other HHs responded no change (23.8 %), increasing (23.8 %) and fluctuates (8.0 %) in the central highlands of Ethiopia.
Table 6. Quantity purchased and price (Birr/unit) of forage/fodder seeds or planting materials per household in central highlands of Ethiopia.

<table>
<thead>
<tr>
<th>Quantity Purchased &amp; Price</th>
<th>Mean</th>
<th>SEM</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa, kg</td>
<td>0.22 (200.0)</td>
<td>0.08 (0.00)</td>
<td>0.05 (200)</td>
<td>0.5 (200.0)</td>
</tr>
<tr>
<td>Vetch, kg</td>
<td>8.33 (9.42)</td>
<td>3.54 (2.83)</td>
<td>1.0 (4.0)</td>
<td>25 (22.5)</td>
</tr>
<tr>
<td>Fodder Grasses (Oats)</td>
<td>48.25 (3.41)</td>
<td>21.35 (0.28)</td>
<td>3.0 (1.50)</td>
<td>360.0 (5.00)</td>
</tr>
<tr>
<td>Napier grass (cuttings)</td>
<td>115 (0.5)</td>
<td>85 (0.00)</td>
<td>30 (0.5)</td>
<td>200 (0.5)</td>
</tr>
<tr>
<td>Fodder Trees (Seedlings)</td>
<td>18 (0.83)</td>
<td>4 (0.17)</td>
<td>10 (0.5)</td>
<td>25 (1.0)</td>
</tr>
<tr>
<td>Fodder Beet, kg</td>
<td>0.38 (87.5)</td>
<td>0.07 (7.5)</td>
<td>0.25 (70.0)</td>
<td>0.5 (100.0)</td>
</tr>
</tbody>
</table>

Numbers in the bracket indicate price of the material; SEM=standard error of mean

Informal forage/fodder seed supply

Only 13.8% of households sold forage seeds. The majorities of the respondents (33.3%) neither sold forage seeds nor gave free of charge while 19.5% of HHs gave free seeds and 5.7% of the HHs sold and also gave free forage seeds. The rest of the respondents (27.6%) were non-adopters (Table 7).

Table 7. Percentage of respondents that practiced informal forage seed supply

<table>
<thead>
<tr>
<th>Forage seed supply</th>
<th>Administrative Zone</th>
<th></th>
<th>Total N=87</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arsi (N=22)</td>
<td>West hewa N=35</td>
<td>North Shewa N=30</td>
</tr>
<tr>
<td>Sell</td>
<td>13.6</td>
<td>5.7</td>
<td>23.3</td>
</tr>
<tr>
<td>Give free</td>
<td>45.5</td>
<td>20.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Sell and also give free</td>
<td>9.1</td>
<td>0.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Neither sell nor give free</td>
<td>18.2</td>
<td>57.1</td>
<td>16.7</td>
</tr>
<tr>
<td>Non-adopters</td>
<td>13.6</td>
<td>17.1</td>
<td>50.0</td>
</tr>
</tbody>
</table>

N = number of respondents

Among the various forage/fodder species, fodder oats and Napier grass were supplied informally by the majority of the HHs. Amounts ranged from 3.0-4000 kg per HH with an average of 262.9 kg for oats and from 4 to 120,000 cuttings with an average of 11183 for Napier grass. Prices were different across locations. A kilo of fodder oats sold with an average price of 3.56 Birr with prices ranging from 2.0 to 5.0 Birr and a cutting of Napier grass was sold with an average price of 0.2 Birr ranging from 0.15 to 0.25 Birr. Vetch seed was sold with an average price of 5.80 Birr/kg ranging from 5.4 to 6.0 Birr/kg. Fodder tree seed amounts of
0.5 to 2.0 kg and from 5 to 40 seedlings were given freely to neighboring farmers while the amount of fodder beet seed sold by the HHs ranged from 5.0 to 20.0 kg. Price of fodder beet seed ranged 100 to 150 Birr per kg with an average price of 125.0 Birr/kg (Table 8).

Table 8. Quantity sold or given free and price (Birr/unit) of forage/fodder seeds or planting materials per household in central highlands of Ethiopia

<table>
<thead>
<tr>
<th>Quantity sold/given free and Price (Birr/unit)</th>
<th>Mean</th>
<th>SEM</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vetch, kg</td>
<td>29.2 (5.8)</td>
<td>18.2 (0.2)</td>
<td>0.01 (5.4)</td>
<td>200.0 (6.0)</td>
</tr>
<tr>
<td>odder Oats, kg</td>
<td>262.9 (3.6)</td>
<td>172.7 (0.4)</td>
<td>3.0 (2.0)</td>
<td>4000.0 (5.0)</td>
</tr>
<tr>
<td>Napier grass, cuttings</td>
<td>11182.8 (0.20)</td>
<td>7968.8 (0.03)</td>
<td>4.00 (0.15)</td>
<td>120,000.0 (0.30)</td>
</tr>
<tr>
<td>Fodder trees seedlings given free</td>
<td>20.0</td>
<td>10.40</td>
<td>5.00</td>
<td>40.0</td>
</tr>
<tr>
<td>Fodder tree seed given free, kg</td>
<td>1.6</td>
<td>0.30</td>
<td>0.50</td>
<td>2.0</td>
</tr>
<tr>
<td>Fodder beet seed, kg</td>
<td>12.5 (125)</td>
<td>7.5 (25)</td>
<td>5.0 (100)</td>
<td>20.0 (150)</td>
</tr>
<tr>
<td>Fodder beet, seedlings given free</td>
<td>125</td>
<td>25</td>
<td>100</td>
<td>150</td>
</tr>
</tbody>
</table>

Numbers in the bracket indicate price/unit of forage/fodder seeds or planting materials; SEM = standard error of the mean

Constraints in seed production and marketing
Most of the HHs responded that the major constraints of seed production were limited availability of land, lack of technical skills, low and unreliable yield, and lack of access to suitable forage species and varieties. Weak and unreliable demand, lack of market information or knowledge, and poor storage facilities are the major constraints in seed marketing. The majority of the respondents lack previous training on forage seed production (Table 9), concerted efforts should be made to create awareness, and skills of smallholder producers in improved forage/fodder crops seed production, management, and marketing. Moreover, in potential niches across diverse agro-ecologies of the country specialized farmer groups involving in forage seed production should be organized to curb existing forage seed supply and market problems.

Non-adopting households
Among the non-adopters, 66.7% were aware of improved forage species while the rest did not have any information about cultivated improved forage/fodder species. Although awareness on the use of improved forage crops is increasing, rate of forage technology adoption is still very low. This is particularly related to poor access of smallholder producers to information and sources of improved forage seeds. About 54.2% of the respondents had no information about the sources of forage seeds (Table 10). Sowing a new pasture or improving an existing natural pasture requires a reliable source of seed or vegetative material of recommended species adapted for the area (HSU, 1994). Farmers must be able to access the planting material easily and cheaply.
Table 9. Proportion (%) of the households having training on forage seed production

<table>
<thead>
<tr>
<th>Variables (Have you received any training on seed?)</th>
<th>Zone</th>
<th>Total N=63</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arsi N=22</td>
<td>West Shewa N=35</td>
</tr>
<tr>
<td>Yes</td>
<td>18.2</td>
<td>25.7</td>
</tr>
<tr>
<td>No</td>
<td>81.8</td>
<td>74.3</td>
</tr>
</tbody>
</table>

N = number of respondents

Table 10. Awareness of non-adopting households on improved forage/fodder species and seed sources in the central highlands of Ethiopia (%)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Zone</th>
<th>Total N=24</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arsi N=3</td>
<td>West Shewa N=6</td>
</tr>
<tr>
<td>Awareness on improved forages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>66.7</td>
<td>83.3</td>
</tr>
<tr>
<td>No</td>
<td>33.3</td>
<td>16.7</td>
</tr>
<tr>
<td>Awareness on seed source</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>33.3</td>
<td>50.0</td>
</tr>
<tr>
<td>No</td>
<td>66.7</td>
<td>50.0</td>
</tr>
</tbody>
</table>

N = number of respondents

Conclusion and Way Forward

The result of this survey showed that there is a huge demand among smallholders for feed but availability of affordable forage seed and lack of information are a constraint to fodder production. A forage seed market exists but is very dynamic/unpredictable and is characterized by a scarcity of market information, unclear market channels and lack of evidence based extension services. A variety of forage seed supply mechanisms exist in Ethiopia, including the formal sectors (national/government forage seed sector, private seed industry/traders/cooperatives, and research institutions) and informal sectors (NGOs, farmers-saved and integrated community-based seed supply systems).

The main forage seed suppliers are public extension and research institutions (formal), NGOs, farmers and farmers groups (informal). The role of private seed enterprises/traders/cooperatives is limited in the studied areas. The formal forage seed production and supply system is not well developed as compared with seed systems of food crops in Ethiopia. Fodder had a low adoption rate in the study area, and the real demand for fodder seed from farmers is still not well quantified.
The lack of knowledge to specify demand for forage seeds, lack of information on suitable species and varieties, and limited technical knowledge about forage seeds have led to very variable and/or low demand for seed among smallholders. Like that of food crops, strong extension services are not given to smallholder livestock producers in the study area as well as at national scale. Hence, services at farm level should get priority action to create awareness and enhance demand and use of improved forage crops by smallholder farmers. Standards and quality issues, including forage certification and labeling are not addressed for forage seeds suppliers. Farmers did not yet understand the economic benefits of forage seed production.

A thorough assessment of the forage seed production and supply systems in different agro-ecologies and farming systems of Ethiopia is required to quantify the real demand for fodder seeds/planting materials. All actors in the seed system should give due attention to knowledge sharing with smallholders. Information that helps to identify suitable species and varieties, with common seed quality standards, seed certification, storage and shipping guidelines must be developed. The development of fodder seed enterprises should be closely linked to profitable livestock enterprises. Studies on the economics of forage seed production under farmers’ conditions are also needed. Future efforts should target seed production in niches within value chain of intensive dairy, fattening, peri-urban livestock production, and market oriented crop-livestock production systems.

References


CIAT., 2003. Developing sustainable seed supply systems. No. 3.


SPSS (Statistical Package for Social Sciences). SPSS statistics Version.17.0.
Strengthening Forage Seed Supply through Farmer-based Seed Production

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Introduction

Ethiopia is one of the developing countries that enjoys large livestock population and the sector constitutes a considerable share of the country’s agricultural economy accounting for 40% of the agricultural Growth Domestic Product (GDP), 19% export earnings (FAO, 2003) and 31% of the total agricultural employment (Getachew, 2003). Population growth, urbanization and income growth in developing countries are fuelling a massive increase in demand for food of animal origin. Increasing demand for livestock products present poor livestock producers with significant opportunities to increase benefits from livestock production through participating in livestock-related markets. However, livestock productivity is among the lowest in Africa, leaving 49% of Ethiopia’s population undernourished (CSA, 1997; FAO, 2001).

Feed shortage and poor quality of available feed remains among the most widespread technical constraints of livestock production (Berhanu et al., 2002) even if market opportunities of livestock and their products are growing. Despite decades of research and development efforts, livestock related interventions, in particular, feeds, showed little evidence of adoption and sustainable impact on the livelihood of the poor (Ahmed et al., 2004; Tesfaye et al., 2008). This has been attributed to a range of factors including poor delivery of technologies and services related to the needs of the poor. However, current initiatives geared towards stimulating the transformation of smallholder production systems to market-oriented systems have been underway in Ethiopia. Use of improved forages is increasing from time to time due to shrinking of grazing areas and their low productivity. Moreover, awareness on uses of improved forages to improve soil fertility and control erosion on marginal lands is increasing. As a result, demand for quality forage seed is huge. However, reliable source of quality seed or vegetative materials of recommended species for different agroecologies of the country at affordable price remained a problem due to lack of organized system for seed production and distribution in the country.
In sub-Saharan Africa (SSA) in general, no single system of seed production is suited to the varying social or environmental situations (ILCA, 1994). Current seed production systems, involving both the public and private sector are focusing only on commercial large-scale food crops seed production and marketing. This has resulted in critical shortage of improved forage crops seed and production is limited to few public institutions and private sectors. In the area of seed development, challenges that exist cannot be dealt only with formal system, and requires an effort from various stakeholders including non-governmental organizations (NGO’s), private sector and farming community.

**Status of Highland Forage Crops Seed Production**

Access to and uses of improved forage seeds are generally low and the most critical problems to improve livestock production and productivity in Ethiopia. In the history of forage development programs in the country, only limited institutions have been involved in forage seed production. Ethiopian Institute of Agricultural Research (EIAR), International Livestock Research Institute (ILRI), Arsi Rural Development Unit (ARDU), Chillało Agricultural Development Unit (CADU) and Fourth Livestock Development Project (FLDP, Ministry of Agriculture) are the principal institutions/projects that had taken initiatives in collection, introduction and evaluation of indigenous and native forage and pasture crops. These institutions/projects laid a remarkable foundation and progress in forage and pasture research and development through developing cultivars and generating information for use in different agro-ecologies of the country.

Holetta Research Center produce and distribute seeds of different forage grasses, legumes and trees that suits to highland agro-ecology. However, the amount of seed produced by the center is very small compared to the huge demand from different stakeholders. As indicated in Tables 1-4, important annual and perennial grasses and legumes and fodder trees seeds are produced and maintained for decades. Although the demand for improved forage seeds is increasing, production of seeds has remained a problem.
Table 1. Seed production (kg) of major perennial grass forage crops and browse trees at Holetta research centre and sub-stations, 2002-2010

<table>
<thead>
<tr>
<th>Forage species</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perennial grasses</strong></td>
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<td>7000</td>
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<td>32,000</td>
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<tr>
<td><strong>Sub-total</strong></td>
<td>41.1</td>
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<td>63.1</td>
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<td>88.5</td>
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<td><strong>Sub-total</strong></td>
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<td>-</td>
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<td>16.3</td>
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<td>18.5</td>
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<td>25,000</td>
<td>7,000</td>
<td>10,000</td>
<td>43,000</td>
<td>20,000</td>
<td>25,000</td>
<td>32,000</td>
<td>45,000</td>
<td>(189,000)</td>
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* Number of root splits distributed for different stakeholders
<table>
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<tr>
<th>Cultivars/Accessions</th>
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<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI-8237</td>
<td>6087.0</td>
<td>6143.7</td>
<td>6604.3</td>
<td>6562.6</td>
<td>6369.2</td>
<td>6572.5</td>
<td>7489.4</td>
<td>7201.2</td>
<td>6840.8</td>
</tr>
<tr>
<td>Lampton</td>
<td>5240.0</td>
<td>5258.4</td>
<td>5221.5</td>
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<td>5343.0</td>
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<tr>
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<td>3476.0</td>
<td>3397.0</td>
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<td>3824.0</td>
<td>4185.0</td>
<td>3612.0</td>
<td>3604.0</td>
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<td>CI-8251</td>
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<td>3340.0</td>
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<td>Grey Algiers</td>
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<td>Jasari</td>
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<td>983.0</td>
<td>1479.0</td>
<td>872.0</td>
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<td>Coker SR.res 80 SA 130</td>
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</tr>
<tr>
<td>C7512/SRPC X 80 Ab2252</td>
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<td>17.6</td>
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<td>-</td>
<td>-</td>
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<tr>
<td>SRCP x 80 Ab 2291</td>
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<td>14.4</td>
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<td>SRCP X 80 Ab2806</td>
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<td>KY to 78394 (Canada)</td>
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<td>-</td>
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<tr>
<td>Germplasm maintenance</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>20260.6</td>
<td>20624.1</td>
<td>21609.8</td>
<td>21881.0</td>
<td>21559.6</td>
<td>21863.3</td>
<td>23545.3</td>
<td>24553.5</td>
<td>25009.1</td>
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</table>
Table 3. Seed production (kg) of different vicia species at Holetta research center and sub-stations, 2002-2010

<table>
<thead>
<tr>
<th>Species</th>
<th>Year</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vicia dasycarpa var. lana</td>
<td></td>
<td>1015.7</td>
<td>253.7</td>
<td>285.0</td>
<td>1140</td>
<td>592.8</td>
<td>578.6</td>
<td>941.0</td>
<td>1715.7</td>
<td>1279.9</td>
<td>7802.3</td>
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<tr>
<td>Vicia sativa</td>
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<td>62.5</td>
<td>41.6</td>
<td>183.0</td>
<td>-</td>
<td>211.8</td>
<td>55.0</td>
<td>168.0</td>
<td>180.0</td>
<td>46.0</td>
<td>947.9</td>
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<tr>
<td>Vicia villosa</td>
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<td>95.9</td>
<td>133.0</td>
<td>218.8</td>
<td>132.0</td>
<td>189.1</td>
<td>201.0</td>
<td>447.0</td>
<td>312.0</td>
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<td>2204.5</td>
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<td>Vicia atropurpurea</td>
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<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>119.0</td>
</tr>
<tr>
<td>Vicia benghalensis</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>36.0</td>
<td>9.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>45.0</td>
</tr>
<tr>
<td>Vicia narbonensis</td>
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<td>-</td>
<td>-</td>
<td>191.0</td>
<td>-</td>
<td>515.0</td>
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<tr>
<td>Vicia dasycarpa, ILRI 2213</td>
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<td>-</td>
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<tr>
<td>Total</td>
<td></td>
<td>1174.1</td>
<td>686.2</td>
<td>756.8</td>
<td>1272.0</td>
<td>1174.7</td>
<td>834.6</td>
<td>1592.0</td>
<td>2407.7</td>
<td>1801.6</td>
<td>11699.7</td>
</tr>
</tbody>
</table>

Table 4. Seed production (kg) of different clover and medics species at Holetta, 2002-2010

<table>
<thead>
<tr>
<th>Species</th>
<th>Year</th>
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<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trifolium decorum</td>
<td></td>
<td>5.9</td>
<td>2.1</td>
<td>-</td>
<td>-</td>
<td>3.7</td>
<td>12.3</td>
<td>7.2</td>
<td>2.5</td>
<td>2.0</td>
<td>35.7</td>
</tr>
<tr>
<td>Trifolium tembense</td>
<td></td>
<td>2.4</td>
<td>9.4</td>
<td>-</td>
<td>-</td>
<td>8.0</td>
<td>-</td>
<td>5.8</td>
<td>1.5</td>
<td>-</td>
<td>27.1</td>
</tr>
<tr>
<td>Trifolium quartinianum</td>
<td></td>
<td>10.3</td>
<td>0.8</td>
<td>-</td>
<td>-</td>
<td>4.7</td>
<td>14.4</td>
<td>10.2</td>
<td>-</td>
<td>5.0</td>
<td>45.4</td>
</tr>
<tr>
<td>Trifolium rueppelianum</td>
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<td>3.6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7.7</td>
<td>1.3</td>
<td>5.3</td>
<td>1.0</td>
<td>-</td>
<td>18.9</td>
</tr>
<tr>
<td>Trifolium steudneri</td>
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<td>5.4</td>
<td>0.7</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.5</td>
<td>1.6</td>
<td>0.4</td>
<td>-</td>
<td>8.5</td>
</tr>
<tr>
<td>Trifolium simense</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.7</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.7</td>
</tr>
<tr>
<td>Sub-Total</td>
<td></td>
<td>27.6</td>
<td>13.0</td>
<td>-</td>
<td>-</td>
<td>24.1</td>
<td>28.5</td>
<td>30.6</td>
<td>5.4</td>
<td>7.0</td>
<td>136.1</td>
</tr>
<tr>
<td>Medicago scutelatta</td>
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<td>-</td>
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<td>-</td>
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<td>2.7</td>
<td>2.6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5.3</td>
</tr>
<tr>
<td>Medicago truncatula</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.7</td>
<td>0.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.4</td>
</tr>
<tr>
<td>Medicago litoralis</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.7</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.7</td>
</tr>
<tr>
<td>Sub-Total</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5.1</td>
<td>3.4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>8.4</td>
</tr>
<tr>
<td>Overall Total</td>
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<td>27.6</td>
<td>13.0</td>
<td>-</td>
<td>-</td>
<td>24.1</td>
<td>33.6</td>
<td>34.0</td>
<td>5.4</td>
<td>7.0</td>
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75
Recent records of seed production at HRC for nearly a decade (2002-2010) indicated that production of only 213.4 tons of different forage crops were possible. Nearly 94% and 5% of total seeds produced were that of oats and vetches respectively (Tables 1, 2 and 3). Perhaps, both forage species are well adapted to highlands and have high demand by producers. A produced seed of perennial grasses and some legumes is very small although seed yield of these species is generally low. *Chloris gayana, Panicum coloratum* and *Pennisetum purpureum* seed/vegetative material demand is increasing and emphasis should be given to these species to satisfy producers’ needs. Nearly, 75% of total seed produced is distributed for different stakeholders in support of forage research and development in the country.

Except few attempts, Ethiopian Seed Enterprise (ESE) does not adequately address forage seed production. ESE being the main public sector seed producer and supplier, except few attempts (Table 5), forage seed production is not yet realized in three decades of operation after reformation. The formal seed system in the country is limited to major food crops. The role of private seed enterprises is also very limited. Seed production and distributions is still restricted to research institutions, some agricultural universities and private seed producers. These put a challenge on access and use of improved forage crops by smallholder farmers to improve livestock production and productivity. The improvement of farmer-seeds, farmer-to-farmer seed exchange and farmer managed seed production could be a potential option for strengthening seed production and access to smallholder farmers. Therefore, establishing and supporting informal seed production on farmers field can fill the existing gap between high demands of improved seeds and very low supply of seeds.

**Strategy for implementation of farmer-based forage seed production: experiences of Holetta research center**

A systematic approach is an important step towards planning and development of farmer based seed production. The approaches used include the following steps:

- Areas where crossbred dairy cattle technologies were disseminated are the focal sites to introduce farmer-based seed production. These areas are selected based on their potential for highland forage crops seed production and livestock production in general, better exposure and awareness to improved technologies, critical feed shortage problem in the areas and increasing interest to produce improved forage crops. Based on this, seven *weredas* including Tikur Inchini, Ejere, Jeldu, Welmera, Dendi, Abashge and Qebena were selected from West Shewa and Gurage zones;
- Discussion with relevant officials in bureau of agriculture and rural development in all *weredas* was made about informal forage seed production on farmers’
field, to involve them in farmers' selection, site selection and technical support throughout the activity;

- Training was provided for extension staffs from bureau of agriculture and local cooperatives on farmer selection, land selection, practices and managements for improved forage crops seed production, quality and management;
- Selection of participatory farmers and land was made by groups formed from agricultural extension staff from respective weredas and research staff from HRC;
- Training was also given to selected farmers from all weredas on land selection, field management, crop management and seed management for improved forage crops seed production;
- Selection of cultivars to match the prevailing climatic and edaphic conditions of selected areas most likely to support high yield and quality seeds were made. Proper choice of site and material for multiplication is an important requirement for seed production;
- Seeds of selected cultivars of Oats sufficient to cover quarter of a hectare were provided for selected farmers with agreement to repay the initial seed received. This is arranged to facilitate supply of seed to other farmers;
- Participatory field activities were made by farmers, extension staff and researchers in land selection, land preparation, planting, field management, harvesting, threshing, cleaning and post harvest seed managements;
- Linking the producers with key stakeholders including bureau of agriculture and rural development, formal and informal seed supply system for improving market access in addition to local exchange system; and
- Field visit and demonstration to create awareness on use and production of improved forage crops.

Table 5. Farmers-based seed production and marketing scheme: seed production under the national seed industry agency, 1998-2001

<table>
<thead>
<tr>
<th>Crops</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
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</thead>
<tbody>
<tr>
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<td>Total</td>
<td>Area (ha)</td>
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<td></td>
</tr>
<tr>
<td>Cereals</td>
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<td>2687</td>
<td>6853</td>
<td>7976</td>
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<tr>
<td>Legumes</td>
<td>-</td>
<td>43</td>
<td>229</td>
<td>381</td>
</tr>
<tr>
<td>Oilseeds</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>67</td>
</tr>
<tr>
<td>Vegetables</td>
<td>2</td>
<td>17</td>
<td>95</td>
<td>30</td>
</tr>
<tr>
<td>Forages</td>
<td>5</td>
<td>22</td>
<td>13</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>742</td>
<td>2769</td>
<td>7200</td>
<td>8454</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crops</th>
<th>Year</th>
<th>Production (tons)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1998</td>
<td>1999</td>
</tr>
<tr>
<td>Cereals</td>
<td>1079</td>
<td>5745</td>
</tr>
<tr>
<td>Legumes</td>
<td>-</td>
<td>26</td>
</tr>
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<td>Oilseeds</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vegetables</td>
<td>8</td>
<td>36</td>
</tr>
<tr>
<td>Forages</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>1087</td>
<td>5813</td>
</tr>
</tbody>
</table>

Source: Yonas et al., 2008
Performance of oats seed production under farmer condition

Oats (*Avena sativa* L.) is a well-adapted fodder crop grown in the highlands of Ethiopia. It is an annual forage crop suitable for integration into mixed crop-livestock farming systems of the highlands (Leulseged, 1981). It can grow on marginal lands that are not suitable for crop production in mixture with vetch which ultimately restore the fertility of the soil. Moreover, it can be produced as a precursor crop in lands preserved for crops growing on residual moisture. Husbandry of oats production is comparatively easy and its adoption by smallholder farmers is high. That is why it was selected for seed production at farmer level to improve its access and use. As indicated in Table 6, yield performances were different across locations owing to varying climatic, edaphic and management practices. A maximum of 2.6 t ha\(^{-1}\) seed was obtained on farmer field at Jeldu while the lowest (0.2 t ha\(^{-1}\)) was also produced from the same location (Table 6). Average yields of 1.24, 1, 0.94 and 0.69 t ha\(^{-1}\) were obtained from Welmera, Ejere, Jeldu and Tikur Inchini respectively. Due to the occurrence of rust at Dendi and waterlogging problem in Gurage zone, oats grown for seed was shifted to be used as hay for livestock. Generally, this work has indicated the possibility to involve farmers in seed production in order to alleviate seed scarcity. Therefore, through improving knowledge base and community empowerment, forage seed production and access to genetic materials could be effective and sustainable which in turn contribute to technology transfer and development of livestock sector.

Table 6. On-farm seed production performance at different weredas in West Shewa and Gurage zones, 2010

<table>
<thead>
<tr>
<th>Weredas</th>
<th>No. of farmers involved</th>
<th>Total cultivated area (ha)</th>
<th>Average yield (q/ha)</th>
<th>Range of yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tikur Inchini</td>
<td>14</td>
<td>3.5</td>
<td>6.87</td>
<td>4-12</td>
</tr>
<tr>
<td>Ejere</td>
<td>5</td>
<td>1.25</td>
<td>10.00</td>
<td>6-16</td>
</tr>
<tr>
<td>Jeldu</td>
<td>20</td>
<td>5</td>
<td>9.44</td>
<td>2-26</td>
</tr>
<tr>
<td>Welmera</td>
<td>5</td>
<td>1.25</td>
<td>12.40</td>
<td>8-16.4</td>
</tr>
<tr>
<td>Gurage zone*</td>
<td>12</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dendi**</td>
<td>5</td>
<td>1.25</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>61</td>
<td>15.25</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* - Poor performance for seed production due to water logging problem and utilized as a hay
** - Poor performance due to rust attack and utilized as a hay
Challenges and Opportunities Identified

In attempt to establish farmer-based forage seed production in the pilot weredas, some challenges were faced. Efforts have been made to improve farmers understanding and skill through training and technical backup via field monitoring. However, some farmers’ preference for hay making due to disease problem (yellow rust) in Dendi, waterlogging problem in Gurage and lack of implementation of recommended practices to the required level are some of the problems identified under field conditions. Moreover, worry of farmers for seed market was also the major challenge to convince them.

Several opportunities were identified on the bases of this experience. Existing high demand for seeds by smallholder farmers and emerging dairy co-operatives were opportunities that solved market questions of the producers. Moreover, the presence of disease and water-logging resistant cultivars of oats and vetch cultivars (though limited) is also an opportunity to sustain the effort in those areas. For quality seed production, matching the environment and cultivars is an important step, so that, evaluation of different genotypes in potential areas for production will be the task for research institutions. Since seed production is a complex task that requires several years of experience, capacity building programs including trainings, field demonstration and workshops on a continuous base should be taken as a strategy to promote forage seed production.

The Way Forward

An increased awareness on use and importance of improved forage crops particularly oats (*Avena sativa*) and vetch (*Vicia dasycarpa, Vicia villosa, Vicia sativa* etc) is fuelling the demand of quality seed by smallholder farmers in the highlands of Ethiopia where high human and livestock population resides. Use of sown forage crops as a feed for livestock has remarkable importance for securing feed and alleviates adverse effect of livestock on natural resource bases. Shrinking of grazing lands, overgrazing, depletion of palatable species richness, invasion of unpalatable species and alien weeds and soil erosion are often cited problems associated with livestock production. Any program aiming to improve livestock productivity and conserve natural resource base should focus on improving feed supply that can only be realized with the use of improved forage and pasture crops under existing situation. A fodder intervention in livestock development is crucial step to contribute to overall system sustainability.

Expansion in the use of improved forage crops requires sustainable supply of quality planting materials (seeds and vegetative) which needs collective action of public and private sectors and farmers for improving production and supply of forage seeds. The current attempt showed that seed production under small-scale farmers has double advantage in that it increases seed production and supply and
also enhances socio-economic welfare of seed producers. Therefore, expanding informal seed production under small-scale farmers’ field in selected potential areas could be one of the practical options to alleviate seed shortage and access by resource poor farmers. However, a need remain to train farmers to enhance their knowledge and skills on quality seed production and management. Strengthening producers especially farmer research group (FRG), emerging dairy co-operatives and private sectors with technical backup and regular field monitoring by relevant agricultural experts and researchers will help a lot to further promote forage seed production. Moreover, seed related research must be done on different forage and pasture crops as seed yield of most species is very low and available information is also limited.

References


The Ethiopian Formal Seed System and Forage Crops

The formal seed system of Ethiopia was restructured in 1979 with the establishment of the Ethiopian Seed Enterprise (ESE). Immediate demand from expanding state farms, the newly established numerous farmers’ producing cooperatives and farmers’ settlement projects were the main reasons behind the establishment of the ESE. There was an interest to increase grain production through the introduction of large scale state owned and cooperative farms. Most of the state farms were established in areas with reliable moisture or irrigated areas and the farmers’ producing cooperatives were organized in the high potential areas. The settlement projects were also implemented to transfer thousands of farmers who were living in recurrent drought affected areas to fertile and moist parts of the country. ESE was intended to serve the high potential areas of the country. Therefore the seed production activities of ESE concentrated mainly on high potential varieties of cereals, pulses and oil crops. Horticultural, fiber and forage crops were given very low emphasis. Forage seeds were introduced later to the formal seed sector in limited quantity. However, forage seed production was not new to the country. Tadesse (1998) reported that the Arsi Rural Development Unit (ARDU) introduced forage and pasture seed in 1970 and used to multiply and distribute mainly oat and vetch seed to the farmers involved in the project. It seems that the formal seed system followed the same pattern of activity since forage seed production activities of ESE focused only on these two forage crops.

Although there were several forage seed organizations and projects, their links with ESE remained very weak. The Ethiopian Institute of Agricultural Research (EIAR) and the herbage seed unit of the International Livestock Center for Africa (ILCA) [now International Livestock Research Institute (ILRI)] were the major sources of breeder seed of forage varieties. The Fourth Livestock Development Project (FLDP) of the Ministry of Agriculture (MoA) exerted another effort to produce and distribute forage seed to small farmers in some parts of the country. The FLDP also initiated contractual seed production with individual farmers and farmer cooperatives. The emphasis of the project was on
production and dissemination of forage legumes and the activity stopped as soon as the project was phased out (Tadesse, 1998). In general, formal forage seed production and distribution led by ESE has remained insignificant over the last two decades. The forage seed sector was dominated by projects and Non Governmental Organizations (NGOs) activities which operated informally. The International Center for Agricultural Research in the Dry Areas (ICARDA) and ILRI contributed to the forage seed sector through a series of joint seed production training courses and workshops.

**Forage Seed Production Efforts by Ethiopian Seed Enterprise (ESE)**

Forage seed production at ESE was limited with very low volume and only two crops. It was not systematically arranged and there were no defined generation stages in the production cycle. Little efforts were made to collect breeder seed of forage varieties from EIAR every year and the supply was also frequently absent. Instead in most years recycled seed was used for certified seed production. Forage seed was not also inspected to determine whether it fulfilled the quality standards set by the then Quality and Standards Authority of Ethiopia (QSAE). ESE later stopped producing vetch seed and has remained with two varieties of forage oats since 2003.

According to the MoARD (2009) about ten forage varieties entered in to the seed production system but currently the ESE mainly focus on seed production of two oats varieties. This shows that most of the seed production was from the informal sector. The varieties were not adequately registered and many which are still produced are not even known by their variety names (Table 1).

<table>
<thead>
<tr>
<th>Forage type</th>
<th>No of varieties under production</th>
<th>Description/Accession</th>
<th>Year of release</th>
<th>Breeder/maintainer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elephant grass</td>
<td>1</td>
<td>ILCA 16984</td>
<td>1984</td>
<td>ILRI</td>
</tr>
<tr>
<td>Tree Lucerne</td>
<td>1</td>
<td>Unknown</td>
<td>1992</td>
<td>HARC</td>
</tr>
<tr>
<td>Rhodes grass</td>
<td>1</td>
<td>Massaba</td>
<td>1984</td>
<td>HARC</td>
</tr>
<tr>
<td>Phalaris</td>
<td>1</td>
<td>Sirossa</td>
<td>1982</td>
<td>HARC</td>
</tr>
<tr>
<td>Vetch</td>
<td>1</td>
<td>Lana</td>
<td>1976</td>
<td>HARC</td>
</tr>
<tr>
<td>Panicum</td>
<td>1</td>
<td>Coloratum</td>
<td>1984</td>
<td>HARC</td>
</tr>
<tr>
<td>Lablab</td>
<td>1</td>
<td>Unknown</td>
<td>1984</td>
<td>HARC</td>
</tr>
<tr>
<td>Trifolium</td>
<td>1</td>
<td>Unknown</td>
<td>1976</td>
<td>HARC</td>
</tr>
<tr>
<td>Oats</td>
<td>2</td>
<td>CI-8237, Lampton</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: MoARD 2009, & ESE’s various reports*
ESE did not plant forage crops on their specialized basic seed farms due to their invasive nature as weeds. Tree species need special production arrangements which the formal seed system is not ready to adopt. Over the seven years from 2003 - 2009, production and sales of forage seed by ESE show a lower and stagnant volume of sales (Table 2). The seed requirement was erratic which made the production plan very difficult. Most of the seed was sold to the Oromia region and some NGOs operating in the pastoral areas. The Somali, South and Afar regions which are dominated by the pastoral communities were not involved in forage seed purchase as expected (Table 3).

Table 2. Oats seed production and sales by the Ethiopian seed enterprise

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (q)</th>
<th>Sales (q)</th>
<th>Total (q)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lampton</td>
<td>CI-8235</td>
<td>Lampton</td>
</tr>
<tr>
<td>2003</td>
<td>45.60</td>
<td>48.10</td>
<td>-</td>
</tr>
<tr>
<td>2004</td>
<td>61.38</td>
<td>48.04</td>
<td>32.7</td>
</tr>
<tr>
<td>2005</td>
<td>49.30</td>
<td>39.65</td>
<td>17.00</td>
</tr>
<tr>
<td>2006</td>
<td>59.71</td>
<td>43.44</td>
<td>50.00</td>
</tr>
<tr>
<td>2007</td>
<td>32.58</td>
<td>28.00</td>
<td>62.00</td>
</tr>
<tr>
<td>2008</td>
<td>144.83</td>
<td>44.68</td>
<td>2.00</td>
</tr>
<tr>
<td>2009</td>
<td>47.6</td>
<td>45.69</td>
<td>1.70</td>
</tr>
<tr>
<td>Total</td>
<td>441.00</td>
<td>297.60</td>
<td>165.40</td>
</tr>
</tbody>
</table>

Source: ESE’s various reports

Table 3. Some customers of the Ethiopian seed enterprise for selling oats seed

<table>
<thead>
<tr>
<th>Buyer</th>
<th>Amount of seed sold (q)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005</td>
</tr>
<tr>
<td>Oromia</td>
<td>-</td>
</tr>
<tr>
<td>Somali</td>
<td>-</td>
</tr>
<tr>
<td>Others</td>
<td>64.00</td>
</tr>
<tr>
<td>Total</td>
<td>64.00</td>
</tr>
</tbody>
</table>

Source: ESE’s various reports

Forage Seed Business Opportunities in the Formal Sector

In Ethiopia the livestock sector is undergoing a rapid commercialization process. Several export abattoirs and live animals exporters are engaged in foreign trade.
The government also considers the sector among those with potential for earning foreign currency both through live export and semi processed meat. According to the Growth and Transformation Plan (GTP) of the Federal Democratic Republic (FDRE) (2010) the export of meat is planned to increase from the current 10,000 to 111,000 metric tons in 2014/15. Higher population growth in the highlands and land scarcity has forced the farmers to seek alternative means of cattle management to meet export targets. Open grazing is already reduced and will be significantly reduced in the future. Enhanced forage production may be the only option to meet feed demand and will require improved seed of superior forage varieties. It is expected that there would be a rise in seed demand of forages from both small farmers and the livestock fattening and dairy resources development farms. The same holds true with the pastoral areas of the country. The GTP (2010) affirms that the focus of agricultural development of the pastoral areas of the country will be mainly on livestock resources development. The introduction of modern technologies which enhance livestock production for local communities is an option for the development of the pastoral areas. Thus forage seed demand would also increase in such areas.

### Challenges

The forage seed business may not attract commercial seed companies at this moment due to their natural lower seed producing capacities. It is obvious that crops with lower seed multiplication capacities are not preferred by commercial seed companies because they require high amount of seed and land for multiplication while their production output is lower. Another problem is related with the lack of experience and knowledge in the area of forage seed technology. Many forage crop seeds need special treatment like scarification and some forage legumes cannot be successfully grown without specific inoculums which again are not readily available and difficult to handle (Mohamed, 2007). Some of them are also biennials or perennials which cannot compete with annual food crop seed production for profitability. Hence, it is extremely difficult to multiply seeds of many of the forage crops under contract with farmers. It was reported from the Somali region, where pastoral communities occupied almost all the rural areas, that there was lack of interest to produce forage crops (Mohamed, 2007). In areas where food crops are important, contract forage seed multiplication is even more difficult due to the lower productivity of forages when seed is produced. Farmers may demand a premium price for the seed produced under contract. This in turn increases the production cost which would be reflected on the final commercial seed price.

### Priorities

In order to promote the forage seed production and supply systems, the following factors need to be given a due attention:
**Maintenance breeding and breeder seed supply**
Systematic breeder seed supply is not possible without proper arrangement of consecutive seed production and supply. Breeder seed was not requested and systematically produced in the past. The first step therefore is to arrange planned maintenance breeding and breeder seed production and supply. It is also necessary to build a strong link between ESE with EIAR and ILRI in material exchange and variety development. New superior varieties are needed to lure the seed companies and those who are working on the informal seed sector to help farmers acquire improved varieties of forage crops.

**Formal seed sector**
At present the formal seed supply of forage crops is very weak and done by a single seed enterprise, the ESE which is not showing strong interest to expand its forage seed production. The demand for forage seed was also insignificant and unreliable and the forage seed business proved less profitable when compared to field crops like bread wheat and hybrid maize. Some sort of subsidy may be necessary at the beginning to stimulate forage seed demand. The subsidy could be removed when the farmers acquire enough knowledge and interest in growing seed and crops of forages. This will help in both contract seed production and seed use among the farming communities.

**Informal seed sector**
It is imperative to strengthen the informal forage seed system to improve the livelihoods of farmers and pastoralists as well as enhance livestock productivity. The experiences of the FLDP showed that farmers could be used as contract seed growers in a semiformal manner using legally binding agreements with individual farmers and farmers’ cooperatives. The contract agreement defined and implemented the obligations of the producers (farmers and cooperatives) and the contractor (the project).

- The project provided seed for initial sowing, provided close supervision and technical backup for the seed plots, purchased the seed in cash at an agreed price at a specific time; and
- The producers managed the crop and produced high quality seed, cleaned the seed after harvest and delivered it at a specified time (MoA, 1991).

It is not clear how the seed was sold back to the users. However, if these contract procedures are adopted with financial support, it is possible to distribute the seed in an informal manner at a reasonable price. The responsibility of coordination of seed production and supply should be given to the agricultural extension services to make it more sustainable. Organizing specialized forage seed cooperatives may also help.
Regulatory and Popularization Activities

Forage seed production is not practically regulated in the formal seed system. This may be due to the current insignificant volume of production. In addition, the current seed regulatory system of the country is not as such efficient to include forage crops. However, most of the forage crop seeds are included in the field and seed quality standards set by QSAE. The standards show higher values in most cases of forage species than those of many other crops. The 1987-88 FLDP forage seed production scheme also set its own seed standard norms, especially minimum germination standards which were lower than those of the QSAE (Table 4). It is not expected that the seed certification scheme of the country would include forage seeds in the near future. Nevertheless, the standards need revision so that they would not pose any obstacle to the expansion of forage seed development.

The other very important activity is the popularization of the available varieties and seed production technologies. At present very few trained professionals are available in the forage seed sector. Field demonstrations and training targeting the different groups are needed to advance the technology and build skills in forage seed production, conditioning and use. It seems that most of these activities are at an initial level and would require sufficient funds at the beginning.

Table 4. Comparison of minimum seed germination standards of some forage crops between QSAE and FLDP

<table>
<thead>
<tr>
<th>Forage species</th>
<th>Minimum Germination Standards (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>QSAE</td>
</tr>
<tr>
<td>Cowpea</td>
<td>85</td>
</tr>
<tr>
<td>Vetch</td>
<td>85</td>
</tr>
<tr>
<td>Lablab</td>
<td>75</td>
</tr>
<tr>
<td>Stylo</td>
<td>60</td>
</tr>
<tr>
<td>Siratro</td>
<td>75</td>
</tr>
<tr>
<td>Clover</td>
<td>70</td>
</tr>
<tr>
<td>Sesbania</td>
<td>65</td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>75</td>
</tr>
</tbody>
</table>

Sources: QSAE (2000) and FLDP (1991)

Stakeholders and their Roles

The seed industry involves many organizations and individuals with defined roles. Neither the formal nor the informal forage seed sectors will develop unless
all concerned stakeholders work together. Fortunately, most of the seed sector public organizations are currently organized under the MoA, who are expected to take the lead role in production. Research, extension and private seed producers, as well as the seed regulatory body, should maintain proper links among themselves. The link between the formal and informal sectors is also vital to ensure that superior varieties and technologies reach the farmers more effectively and efficiently.

**Conclusion and Recommendation**

Forage seed production and distribution is insignificant in Ethiopia and the formal seed system has remained weak throughout its history, although the first activity in production and distribution dates back to the beginning of the seventies. Ethiopia has a high livestock population and has favorable environments to produce most of the forage species and forage varieties have been developed by the national agricultural research system. Past poor performance of the forage seed sector coupled with the existing huge potential of forage and animal production is putting attention back to the possibility to develop the forage seed sector. Both the formal and the informal sectors did not consider that forages should be improved for better performance. Maintenance breeding and breeder seed supply have proved to be ineffective and should be further emphasized coupled with the other activities and institutional arrangements required to promote forage seed production and supply systems in the country.

**References**

Forage Seed Supply in Ethiopia: Some Thoughts on Status and How it Might Evolve

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²International Food Policy Research Institute, Washington DC, USA

Status of livestock feeding

Feed is regularly identified as a key constraint to livestock production in Ethiopia. However, such statements usually refer to market-oriented livestock production where animals are kept for production of milk and meat. In this case, feed is certainly in short supply although one could argue that for subsistence production, animals are being fed appropriately for their main functions of providing draught power, manure and for storage of capital.

Market-oriented livestock production is on the increase in Ethiopia as evidenced by an expanding fattening industry with the emergence of a number of feedlots around Modjo and Adama. According to Ethiopian Revenues and Customs Authority’s meat and live animal export performance data, meat export volume increased from 870 tons in 2000/01 to 7,468 tons in 2008/09. The country’s export performance reached its peak in 2005/06 with export of 7,917 tons of meat. Similarly, the number of live animals (cattle, camels, sheep and goats) exported has also recorded a dramatic increment during this period by rising from 4,919 to 241,683 reaching its peak in 2007/08 with the export of 297,644 head of live animals. The export value mounted from USD 0.2 million to USD 53.1 million (Ethiopia Sanitary and Phytosanitary Standards and Livestock and Meat Marketing Program, 2010). Urban dairy production is also expanding in response to growing urban populations and rising incomes. This move to more market-oriented production is leading to a growing demand for high quality feeds to sustain more productive animals. High quality feeds include protein sources such as oilseed cakes and milling by-products but also planted forages which can supply moderate amounts of crude protein and produce high biomass yields.

Rising human populations have placed increasing pressure on land resources leading to a gradual shift in the contribution of different feed sources to livestock diets. Traditionally livestock were grazed on common resources but expansion of crop lands has led to dwindling pasture resources and greater availability of crop residues. Studies have indicated that there is a deficit of about 12.3 million tonnes of dry matter in Ethiopia. For various reasons, crop residues and agro-
industrial by-products are not adequately utilized. Cultivation of forage is not widely adopted and commercial feed production is not developed (Ofcansky and Berry 1991). In a recent study on dairy intensification in Ethiopia, in which groups of farmers were interviewed in 56 villages across Amhara and Oromiya Regions, almost 100% of respondents indicated that stall feeding has increased in the last 10 years while grazing has decreased (authors’ unpublished data). In the same study the proportion of the diet accounted for by dry fodder, mainly crop residues, was found to be substantial (Table 1).

The Need for High Quality Feed

The high proportion of crop residues in Ethiopian livestock diets means that such diets are unable to support high rates of animal productivity. There is a need for additional nitrogen to improve intake and nutrition of crop residue-based diets. Planted forage is a possible means of upgrading diet quality. In Indian dairy systems for example a reasonable proportion of the diet comes from legumes such as berseem which are grown as dedicated livestock feeds (NIANP 2003). Fodder has a low adoption rate in Ethiopia however, for a range of reasons; landholdings are small and available land tends to be used for producing staple cereals; there is minimal confinement of animals so that planted forages are subject to grazing damage; growing planted fodder is relatively knowledge intensive (Cramb 1999); and forage seed is not readily available at farm level.

Table 1. Feed composition by market quality

<table>
<thead>
<tr>
<th>Market quality</th>
<th>High1</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share of grazing and feeding</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>grazing %</td>
<td>44</td>
<td>44</td>
<td>53</td>
</tr>
<tr>
<td>stall feeding %</td>
<td>56</td>
<td>56</td>
<td>47</td>
</tr>
<tr>
<td>Stall feeding composition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dry fodder %</td>
<td>58</td>
<td>64</td>
<td>63</td>
</tr>
<tr>
<td>green fodder %</td>
<td>17</td>
<td>25</td>
<td>28</td>
</tr>
<tr>
<td>concentrate %</td>
<td>25</td>
<td>11</td>
<td>9</td>
</tr>
</tbody>
</table>

1High market quality for our purposes denotes areas where procurement channels for milk are reasonably advanced in the country in question. In Ethiopia, high market quality areas would be typified by having a functioning milk co-operative with several hundred members or the more typically the presence of milk collection systems run by private milk processing companies. Low market quality would be characterized by a predominance of farmer-to-farmer exchange of milk with very little by way of organized milk collection, bulking, processing and wider distribution.
One reaction to slow adoption has been to “push” planted fodder through the research and extension system. This has had limited long-term success as evidenced by the still very limited use of planted fodder in common smallholder practice. Among the reasons for this lack of success has been the failure to develop sustainable seed delivery mechanisms. Ethiopia’s formal seed system is largely focused on major cereals like maize, wheat, and teff (Spielman et al., 2010). Furthermore, introduction of high quality fodder has not been adequately connected to markets for livestock products. Another barrier to success is that forages require considerable technical input to succeed.

**Role for Private Sector to Address the Seed Constraint**

An alternative to relying on public sector bodies to sort out delivery mechanisms for planted fodder would be to foster small-scale entrepreneurs to develop forage seed businesses and market forage seed to smallholders; small-scale entrepreneurs could include farmers, small-scale seed producers and local agribusiness operations. This is also challenging however because entry into seed production is risky. This is partly because of the long supply chain and high transaction costs between farm and market. Feed is already an input into livestock production enterprises that needs to be converted to livestock products to realise cash income. Forage seeds are a further input before even the feed is produced. Thus the forage seed market is subject to “derived demand”. In other words, the supply, demand and price of seed are derived from the market for the actual crop; seed is an intermediary product, not an end in itself.

Another problem is that of asymmetrical information: seed sellers know about a seed’s quality ex ante, but farmers only find out ex post, thus creating the need for credible seed certification or truth-in-labeling systems that are currently of limited importance in Ethiopia’s existing forage seed system. There is also the problem of market uncertainties: farmers’ preferences, weather patterns, and market conditions changing rapidly, making the selling of seed a difficult and risky business.

There is of course already a steady trade in forage seeds in Ethiopia but the buyers are mainly development NGO’s who have sufficient resources to pay “non-economic” prices for seeds—above-market prices designed to ensure the seed supply and improve the economic or social welfare of those supplying the seed. This had led to a rather distorted seed market placing forage seeds out of the reach of ordinary farmers. For example, one nascent commercial seed trader in Ethiopia sells almost his entire stock to development NGO’s and government extension offices (in 2009, 60% to NGO’s, 38% to government agencies, 2% to private individuals; Eden Field Seeds, pers comm.). Similarly, most seed from
ILRI’s Forage Seed Unit is supplied to development agencies (Table 2) (Hanson and Tedla, 2010).

Table 2. Distribution of seeds from the ILRI Herbage Seed Unit from 1990 to 2010

<table>
<thead>
<tr>
<th>Type of recipient</th>
<th>Number of requests</th>
<th>Number of seed samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development Aid/NGOs</td>
<td>293</td>
<td>2220</td>
</tr>
<tr>
<td>Educational institutions</td>
<td>65</td>
<td>367</td>
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<tr>
<td>Government institutions</td>
<td>174</td>
<td>1236</td>
</tr>
<tr>
<td>Private agribusiness</td>
<td>33</td>
<td>249</td>
</tr>
<tr>
<td>Research institutions</td>
<td>119</td>
<td>879</td>
</tr>
<tr>
<td>Smallholder farmers</td>
<td>63</td>
<td>162</td>
</tr>
</tbody>
</table>

A further difficulty with the forage seed market relates to the fact that most forages are open pollinated varieties and therefore replicable on farm. This means that forage seed suppliers may do themselves out of business in a year or two, once sufficient material is in the market (although this has not limited forage seed entrepreneurs in other countries such as India). Finally entrepreneurs face constraints such as access to credit, access to land, limited business skills or experience, lack of readily available and high quality basic/certified seed, and limited access to other physical and human capital needed to produce seed at any scale.

**Research Needs**

There is a need to upgrade feed quality to support more intensive livestock production in Ethiopia and planted forages could play a role. However, past efforts to promote uptake of planted forages have not had the impact anticipated. An alternative approach would be to foster private sector seed development, but this solution is not without significant challenges. We now come to some knowledge gaps that could be addressed through research.

Firstly, we suggest there is a need to assess supply and demand for improved forages for livestock to support targeting of hot spot areas (high intensification, market orientation and supportive institutions) for interventions, considering trade-offs with existing uses of land, labour and capital and matching forage species to niche. This could involve combining suitability maps for forages
based on agro-ecological conditions with information on demand for livestock products such as milk and meat, distance to market and so on.

Second, there is a need to assess the extent and stability of demand for forage seed, willingness to pay among farmers and indicative net margins for potential entrants. So far, prices for forage seed has largely been determined by the prices offered by development NGO’s and extension offices. We need to further know what value farmers would place on forage seed to be able to make some economic assessments of the long-term prospects for seed suppliers in a market involving seed suppliers and farmers.

Third, we need to look beyond Ethiopia to identify different context-specific institutional models for forage seed supply and agribusiness development and match these models with farmer needs. This could include looking at case studies from other countries such as India, Thailand (Phaikew and Hare, 1998) and others where successful models have been developed. Work with relevant actors will be essential to stimulate implementation of such models in the Ethiopian context.

Fourth, we need to find ways to link actors with relevant sources of knowledge and build capacity of various actors in forage and food-feed crop seed systems development e.g. through a forage seed working group convened by an appropriate actor with long term interest in the issues.

Finally, we need to assess the enabling environment for development of private sector seed supply and needs for policy development to support forage seed supply and agribusiness development.

**Conclusion**

Planted forage has been slow to catch on in Ethiopia for a range of reasons as we have seen. A continuing strategy of “technology push” is unlikely to lead to change. We argue that a change of emphasis is needed potentially including making things easier for private sector seed suppliers to become viable business concerns. To aid this process we have suggested a series of knowledge gaps that need to be addressed, through research, to support such a transition.
References


Seed Research and Development of Perennial Forage Crops in the Central Highlands

Getnet Assefa and Gezahegn Kebede
Ethiopian Institute of Agricultural Research
P.O.Box, 2003, Addis Ababa, Ethiopia

Introduction

The highlands of Ethiopia are characterized by crop-livestock mixed farming systems and inhabited by high human and livestock populations. About 88% of the human, 75% of the cattle, 75% of the sheep and 34% of the goat population in Ethiopia are found in the highlands. This overstocking is one of the major reasons for severe degradation of the natural resource base resulting in poor animal nutrition (CSA, 2008). Despite enormous contribution of livestock to the livelihood of farmers, scarcity of feeds in both quantity and quality is a common problem for the development of viable livestock industries in Ethiopia and many developing countries (Sere et al., 2008). Traditional livestock production system mainly depends upon poor pasturelands and crop residues which are usually inadequate to support reasonable livestock production (Assefa, 2005). Currently, with the rapid increase in human population and increasing demand of food, grazing lands are continuously degraded due to poor management and steadily shrinking being converted to arable lands (Muriuki, 2003). Crop residues provide on average about 50% of the total feed source for ruminant livestock and its contribution reach up to 80% during the dry seasons of the year in the highlands of Ethiopia (Adugna, 2007). These feed resources are high in fiber, with low to moderate digestibility and low levels of nitrogen (Tsige, 2000), thus resulting in insufficient nutrient supply and low productivity (Hindrichsen et al., 2004). These poor roughage feeds have to be complemented with cultivated forage and pasture species of high forage yield with reasonable quality if any meaningful production level is to be expected from livestock (Getnet et al., 2003). Berhanu et al., (2003) also reported that improving animal nutrition through adoption of sown forage could substantially increase livestock productivity.

Holetta Research Center, representing the cool highland agroecologies in Ethiopia, is one of the oldest centers where forage and pasture crops research has been conducted for more than 4 decades. It is also the center where most of the different collection of forage crops of exotic and local planting materials were tested and regenerated. Screening of different forage crops was made both at accessions and species level and the promising materials were promoted for
production. Flower setting and seed production potential were among the selection criteria of forage crops, however, most of the evaluations were focused on environmental adaptation and biomass productivity. Research results indicated that seed production of perennial forage grasses meet with considerable difficulties that needs skills, close follow up and better management from planting to cleaning when compared to annual forage crops. The eventual step of large scale production of improved forage species would be critically hindered and all the preceding plant introduction and evaluation works will be wasted unless seed is produced in sufficient amount and available for users (Getnet et al., 2003). Generally, not only research on forage seed production technologies was very limited in the country, but also the generated information on seed production technology and productivity were not accessible for various end users. Therefore, the objective of this paper is to review forage seed production technologies of important perennial forage species at and around Holetta research center and suggest possible options for future strategy under the highland ago-ecological conditions.

**Findings**

**Major perennial forage crops**

Different temperate and tropical perennial forage species were evaluated for their adaptation, forage productivity, seed yield and various agronomic merits at Holetta and its sub stations in the central highlands of Ethiopia. The research results indicated that tropical perennial grasses were well adaptive, productive, persistent, and promising for many parameters assessed compared to the temperate species. Perennial forage species enhance long term forage production and have been shown to provide numerous positive environmental effects such as improvement of soil fertility, reduction of erosion and control of nitrate leaching (Stork and Jerie, 2003; McCallum et al., 2004). Among the tested perennial grass species, *Chloris gayana* (Rhodes grass cv. Massaba), *Panicum coloratum* (Colored guinea grass), *Phalaris aquatica* (Phalaris/Harding grass cv. Sirossa) and *Pennisetum purpureum* (Napier/Elephant grass-accessions ILCA-14983 and 14984) are well adaptive and promising in terms of forage productivity and different agronomic merits in the highlands.

Despite a lot of species and varieties of perennial forage legumes have been tested for several years, only very few adaptive and productive legume species were identified for the highlands. Although *Medicago sativa* (alfalfa) is promising in some places of the highlands, it has been failed to establish after germination due to dumping off disease and soil acidity problems in many testing sites. Tropical legumes such as *Desmodium uncinatum* (cv. Silver leaf)
are very difficult to establish because they are very sensitive to frost especially in the first year. However, if the legumes once escape these problems during the establishment year, they perform very well in the following production years. Lotus species such as *Lotus corniculatus* (birds-foot trifoil) and *Lotus uliginosus* (big trifoil) are promising perennial forage legumes for most of the highland areas of Ethiopia. These species were established very well, gave relatively better herbage yield and remained green during the dry season of the year. However, its seed yielding performance was lower at Holetta but was found better in areas like Sinana (Bale). Though expensive and labor intensive, lotus can be propagated vegetatively and established very well.

Among several browse trees in the tropics, *Chamaecytisus palmensis* (tagasaste/tree lucerne) is well adapted and productive in terms of both herbage and seed in the cool tropical highlands up to altitudes of 3,000 m and is one of the few fodder trees that can withstand frost as low as -9°C in the tropical highlands (*Cook et al.*, 2005). Studies on nutritional characteristics of tagasaste in Ethiopia indicate that it has high crude protein (CP) of 18%, in vitro dry organic matter digestibility (DOMD) of 71% and perfect nutrient release synchrony index (*Seyoum, 1995*). All these results are indicative and suggest the enormous potential of tagasaste as a supplement for low quality tropical roughage feed sources. Most legume trees have problems as feed supplements to animals, which is associated with the presence of various secondary metabolites such as tannins that hinders their efficient utilization hence methods to improve palatability of this promising species should be studied. Sesbania sesban is also a good browse tree especially in warmer and frost free areas, but it is short lived compared to tagasaste.

**Highland Perennial Forage Grasses**

**Effect of clearing dates, methods and age at harvest on seed yield**

*Chloris gayana* (Rhodes grass cv. Massaba) and *Panicum coloratum* (Colored guinea grass) were used to test the effect of clearing dates, methods and age at harvest on their seed yield performance at Holetta Research center on a well-drained Nitosol for four years. The average annual rainfall of the testing site during the experimental periods was 1011 mm. The rainfall of the experimental site is bimodal and about 70% of the precipitation falls in the period from mid June to mid September, while the remaining 30% usually falls during the short rains between February and May. The trial was laid out separately for each grass species in a split plot design in three replications. The main plots were management practices, in which the forages were cleared by burning and cutting and the sub plots were six clearing dates at an interval of 10 days starting from 15th April until late June. The experimental seedbeds were prepared following
the recommended tillage practice and 15 kg ha\(^{-1}\) seeding rate was used for both grasses at sowing. Fertilizer at the rate of 18/46 N/P\(_2\)O\(_5\) kg ha\(^{-1}\) was applied at planting and 34 kg N ha\(^{-1}\) annually in the following years.

The effect of clearing dates on seed yield of Rhodes and Colored guinea grasses were ranged from 206.9 to 228.6 kg ha\(^{-1}\) with a mean yield of 215.9 kg ha\(^{-1}\); and form 113.5 to 158.2 kg ha\(^{-1}\) with a mean yield of 131.1 kg ha\(^{-1}\) respectively. This result showed that rhodes grass comparatively gave higher seed yield at Holetta when compared to Colored guinea grass (Getnet and Tadesse, 1996) (Table 1). This result generally indicated that clearing date had an effect on the seed productivity of both Rhodes and Colored guinea grasses. Getnet et al., (2004) reported that the amount and distribution of rainfall during the clearing dates (short rains) might contribute a lot to the overall seed productivity than the clearing date effect per se.

Table 1. Effect of clearing dates on average (3 years) seed yield (kg ha\(^{-1}\)) of rhodes and colored guinea grasses at Holetta.

<table>
<thead>
<tr>
<th>Clearing dates</th>
<th>Seed yield (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rhodes</td>
</tr>
<tr>
<td>Mid April</td>
<td>195.0</td>
</tr>
<tr>
<td>Late April</td>
<td>228.6</td>
</tr>
<tr>
<td>Mid May</td>
<td>225.0</td>
</tr>
<tr>
<td>Late May</td>
<td>206.9</td>
</tr>
<tr>
<td>Early June</td>
<td>218.3</td>
</tr>
<tr>
<td>Late June</td>
<td>221.3</td>
</tr>
<tr>
<td>Mean</td>
<td>215.9</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>41.5</td>
</tr>
</tbody>
</table>

Average seed yield of both Rhodes and Colored guinea grasses were significantly affected by the two stubble clearing methods of burning and cutting (Table 2). Stubble clearing using burning method gave 227.6 and 145.2 kg ha\(^{-1}\), while cutting gave 204.1 and 117 kg ha\(^{-1}\) seed yield for rhodes and colored guinea grass respectively. In both forage types, stubble clearing using burning method gave significantly higher seed yield than cutting. The average seed yield was increased by 11.5% and 24.1% by using stubble burning method when compared to cutting for Rhodes and Colored guinea grasses respectively. However, Getnet et al., (2004) reported that because of vigorous juvenile regrowths of grasses during the short rains, use of burning method to clear the stubble was so difficult, hence, cutting is preferred. Despite the highest seed
yield of Rhodes grass for both clearing methods, higher yield difference between the two clearing methods was observed in Colored guinea grass. The stubble of perennial forage grasses should be removed after seed harvest to maintain high seed yields in the following production years. Boonman (1993) reported that complete removal of crop residue by close clipping and burning treatments could significantly increase seed yields supporting the hypothesis that the elimination of older, non-productive tillers and removal of residue allowing for new tiller development at the soil surface. Residue management is critical for maintaining high seed production because sunlight penetration to the crown is critical to grass plants recovering from harvest. Field burning has been an important residue management practice in cool-season grass seed crops. Historically, residue burning has been justified on the basis of disease control (Hardison, 1980), weed control (Rolston et al., 1997), and stimulation of seed yield (Chilcote and Young, 1991).

Table 2. Effect of stubble clearing methods on average (three years) seed productivity (kg ha\(^{-1}\)) of rhodes and colored guinea grass grasses at Holetta

<table>
<thead>
<tr>
<th>Method of clearing</th>
<th>Seed yield (kg ha(^{-1}))</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rhodes</td>
<td>Colored guinea</td>
<td></td>
</tr>
<tr>
<td>Burning</td>
<td>227.6</td>
<td>145.2</td>
<td></td>
</tr>
<tr>
<td>Cutting</td>
<td>204.1</td>
<td>117.0</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>215.8</td>
<td>131.1</td>
<td></td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>16.3</td>
<td>23.8</td>
<td></td>
</tr>
</tbody>
</table>

Plant age at harvest had an effect on seed yield of rhodes and colored guinea grasses at Holetta research center (Table 3). Seed yield of 243.1 and 177.4 kg ha\(^{-1}\) was obtained during the second year of planting (first harvest) for rhodes and colored guinea grasses respectively. However, the amount of seed yield obtained in subsequent harvesting years was decreased for both grasses. The seed yield obtained during the third year of planting (second harvest) decreased by 48.0 and 43.6% compared to second year of planting for rhodes and colored guinea grass respectively. Experience in the highlands around Holetta, Sinana, Adet and Kulumsa, showed that rhodes and colored guinea grasses usually do not produce viable seed in the first year of planting. In these cool highlands areas, perennial forage grasses establishment is very poor, seedling growth is stunted due to low soil and air temperatures, and wet conditions (Getnet et al., 2004). However, in warmer areas such as Bako, Hawassa and Kitale (Kenya), these grasses produce very good amount of seed in the first year of planting (Boonman, 1993; Alemu, 1998).
Seed response on harvesting stages

The tropical grasses rhodes grass and colored guinea grass and the temperate grass Phalaris aquatica (Phalaris/Harding grass) were used to evaluate the effect of seed harvesting stage on yield at Holetta on drained red nitosol. The experiment was laid out in a replicated split plot design. The grass species were used as a main plot and six harvesting stages at a week interval starting from full flowering as a sub plot treatment. The grasses were sown at a seeding rate of 15 kg ha\(^{-1}\) in early June. DAP fertilizer at the rate of 18/46 N/P\(_2\)O\(_5\) kg ha\(^{-1}\) was applied at planting. Moreover, urea fertilizer at the rate of 23 N kg ha\(^{-1}\) was also applied annually in the second year and then after.

<table>
<thead>
<tr>
<th>Age at harvest (year)</th>
<th>Seed yield (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rhodes</td>
</tr>
<tr>
<td>First</td>
<td>*</td>
</tr>
<tr>
<td>Second</td>
<td>243.1</td>
</tr>
<tr>
<td>Third</td>
<td>164.3</td>
</tr>
<tr>
<td>Fourth</td>
<td>190.0</td>
</tr>
<tr>
<td>Mean</td>
<td>199.2</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>29.3</td>
</tr>
</tbody>
</table>

*No harvestable seed yield produced

Harvesting stages had a significant effect on seed yields of the three perennial forage species (Table 4). Rhodes grass (148.8 kg ha\(^{-1}\)) produced the highest average seed yield over the harvesting stages followed by colored guinea (84.8 kg ha\(^{-1}\)) and phalaris grass (75.4 kg ha\(^{-1}\)). The seed yield of rhodes grass increases up to third weeks after full flowering and then continuously decreasing when the harvesting stages after full flowering was delayed. The seed yield of colored guinea grass continuously increased until fifth weeks after full flowering and produced the highest yield at fifth (114.3 kg ha\(^{-1}\)) weeks after full flowering. Phalaris grass gave better seed yield at fifth and sixth weeks after full flowering compared to the other harvesting stage. Generally, seed harvesting stage has the highest effect on seed yield of rhodes grass followed by colored guinea and phalaris grasses. Research experience indicated that most tropical grasses like rhodes and colored guinea grasses needed sweating, which gives about twice the seed yield of direct heading, because maturation can be completed in the moist condition inside the stack. According to Getnet et al., (1996), keeping harvested seeds of most tropical grasses up to two years in storage improved germination.
due to post harvest maturation of dormant seeds in the highlands. Generally, seed yield of forage crops is highly reduced if proper harvesting schedule is not applied according to species, location and environmental conditions (Alemayehu and Robertson, 1987).

**Response of seed on fertilizer application**

The effect of manure and nitrogen fertilization on seed productivity at perennial grasses was evaluated at Holetta Research Center. The seeds were sown broadcast on a well prepared seedbed using 15 kg ha\(^{-1}\) seeding rate. The treatments were laid out in a split plot design in four replications using the grass species as main plots and partially decomposed cattle manure at the rate of 5, 10 and 15 t ha\(^{-1}\) and nitrogen fertilizer at the rates of 23, 46, and 92 kg N ha\(^{-1}\) in the sub plots leaving one unfertilized plot as a control. Nitrogen fertilizer was split in to two so that half was applied at planting and the other half at tillering. But Phosphorous was applied at the rate of 46 kg P\(_2\)O\(_5\) ha\(^{-1}\) across all nitrogen plots in the establishment year. All the grasses set seed starting from the second year as the area is cool and grasses grow slowly during the establishment year.

<table>
<thead>
<tr>
<th>Harvesting stage (Weeks after full flowering)</th>
<th>Seed yield (kg ha(^{-1}))</th>
<th>Rhodes</th>
<th>Colored</th>
<th>Phalaris</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>123.2</td>
<td>45.5</td>
<td>51.9</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>144.6</td>
<td>75.2</td>
<td>85.0</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>185.5</td>
<td>79.8</td>
<td>64.1</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>175.4</td>
<td>110.9</td>
<td>77.9</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>146.6</td>
<td>114.3</td>
<td>86.9</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>117.6</td>
<td>83.0</td>
<td>86.4</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>148.8</td>
<td>84.8</td>
<td>75.4</td>
</tr>
</tbody>
</table>

The result showed that manure and N fertilization had a significant effect on average seed yields of rhodes grass. The mean seed yield of rhodes grass for different levels of manure and N fertilization ranged from 145.8 to 194.1 kg ha\(^{-1}\) with a mean of 172.9 kg ha\(^{-1}\). The mean seed yields of rhodes grass were consistently increased with increasing level of manure and N fertilizers application. There was no significant difference observed among the various levels of manure application but the highest seed yield was recorded for higher
level (15 t ha\(^{-1}\)) of manure application. But seed yield among different N fertilization rates had a significant effect and the highest seed yield was obtained by applying high (92 kg ha\(^{-1}\)) amount of N fertilizer. Generally, the mean seed yield of rhodes grass with application of manure and N fertilizers was comparatively higher when compared to seed yields of unfertilized plots.

Seed yields of colored guinea grass in response to application of different manure and N levels were inconsistent but, showed an increasing trend with an increase in manure and N levels and the highest mean seed yield (151.9 kg ha\(^{-1}\)) and (123.7 kg ha\(^{-1}\)) was obtained in response to 92 kg N ha\(^{-1}\) and 10 t ha\(^{-1}\) manure application respectively. Mean yields in response to the different manure levels were lower (112.3 kg ha\(^{-1}\)) than the control treatment (127.7 kg ha\(^{-1}\)) indicating that colored guinea grass is less responsive to manure application than rhodes and phalaris grasses in terms of seed yield. Generally, no significant difference on seed yield was observed among the different manure levels; however, the difference was significant among the N levels.

### Table 5. Response of rhodes, colored guinea and phalaris grasses to manure and N fertilizer application on seed yield (kg ha\(^{-1}\)) at Holetta.

<table>
<thead>
<tr>
<th>Fertilizer levels</th>
<th>Seed yield (kg ha(^{-1}))</th>
<th>Rhodes</th>
<th>Colored guinea</th>
<th>Phalaris</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 t ha(^{-1})Manure</td>
<td>167.6</td>
<td>106.4</td>
<td>156.8</td>
<td></td>
</tr>
<tr>
<td>10 t ha(^{-1})Manure</td>
<td>173.7</td>
<td>123.7</td>
<td>180.9</td>
<td></td>
</tr>
<tr>
<td>15 t ha(^{-1})Manure</td>
<td>193.5</td>
<td>106.9</td>
<td>165.6</td>
<td></td>
</tr>
<tr>
<td>23 kg ha(^{-1})Nitrogen</td>
<td>145.8</td>
<td>126.9</td>
<td>201.2</td>
<td></td>
</tr>
<tr>
<td>46 kg ha(^{-1})Nitrogen</td>
<td>170.5</td>
<td>121.2</td>
<td>149.0</td>
<td></td>
</tr>
<tr>
<td>92 kg ha(^{-1})Nitrogen</td>
<td>194.1</td>
<td>151.9</td>
<td>163.4</td>
<td></td>
</tr>
<tr>
<td>Control (No fertilizer)</td>
<td>165.4</td>
<td>127.7</td>
<td>158.4</td>
<td></td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>172.9</td>
<td>123.5</td>
<td>167.9</td>
<td></td>
</tr>
<tr>
<td><strong>LSD (5%)</strong></td>
<td>44.4</td>
<td>24.5</td>
<td>21.5</td>
<td></td>
</tr>
</tbody>
</table>

On the other hand, phalaris grass gave significant response to application of manure and N fertilizer in terms of seed yield with a mean yield of 167.9 kg ha\(^{-1}\) (Table 5). Seed yield trend in response to the different manure and N fertilizer levels was inconsistent and higher mean seed yield (201.2 kg ha\(^{-1}\)) and (180.9 kg ha\(^{-1}\)) was obtained in response to 23 kg N ha\(^{-1}\) and 10 t ha\(^{-1}\) manure application respectively. Significant seed yield variations have been realized among the
different manure and N fertilizer levels applied. According to Getnet et al., (2003), the overall seed productivity of the three grasses evaluated under Holetta condition was better in response to the initially applied high levels of manure and N fertilizer (15 t ha$^{-1}$ manure and 92 kg N ha$^{-1}$). Generally, the response of perennial grasses to fertilization was found very good, which implies the importance of applying adequate amount of fertilizer in production of forage seeds from perennial grasses.

**Napier grass establishment methods**

Napier grass/Elephant grass (*Pennisetum purpureum*) is one of the most important perennial forage grass which can produce biomass yield of 20-30 tons of dry matter/ha/year with good agronomic and management practices (Farrell et al., 2002). Napier grass has many uses in different parts of the world which include fire breaks, mulch, green manure, wind break, grazing, soil erosion control and constituent of fish ponds (Farrell et al., 2002). For best establishment and productivity, Napier grass should be planted at 40-50 cm spacing in rows of 75 cm. Napier grass propagated vegetatively using stem cuttings, root splits and shoot tips which usually vary across agro-ecologies. Vegetative propagation methods from stem cuttings, root splits and shoot tips were tested over locations and the result showed that root splits and shoot tips are highly successful than stem cuttings in cooler highlands whereas stem cuttings are almost equally important to root splits and shoot tips in warmer agro-ecological condition. All forage crops respond dramatically to good management practices, hence, higher yields, better forage quality, and improved persistence result from paying attention to the basics of good forage management conditions.

Napier grass survival rate using different establishment methods ranged from 26 to 71% and from 27 to 73% on flat and BBF seedbeds at Ginchi respectively (Table 6). Generally, mean plant survival rates on both seedbed types were higher for plots established from root splits (72%) followed by shoot tips (40.5%). Use of appropriate and easily applicable establishment methods for the different production, agroecological and soil conditions normally has remarkable contribution on success of napier grass production.
Table 6. Average percent establishment performance of napier grass planted with different methods of establishment on flat and BBF seedbeds at Ginchi.

<table>
<thead>
<tr>
<th>Methods of establishment</th>
<th>Types of seedbed</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flat</td>
<td>BBF*</td>
</tr>
<tr>
<td>Stem cuttings, both two nodes buried</td>
<td>27</td>
<td>34</td>
</tr>
<tr>
<td>Stem cuttings, only one node buried</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>Root splits</td>
<td>71</td>
<td>73</td>
</tr>
<tr>
<td>Shoot tips</td>
<td>37</td>
<td>44</td>
</tr>
<tr>
<td>Mean</td>
<td>40.3</td>
<td>44.5</td>
</tr>
</tbody>
</table>

*BBF= Broad Bed and Furrow

Highland perennial forage legumes

Effect of lotus establishment methods on seed production

Lotus species is an erect, tap rooted perennial legume that resembles lucerne in its use and management. While it is much less productive than lucerne, it tolerates lower fertility. In contrast to lucerne, some cultivars tolerate low pH soils. While its water-logging tolerance is only fair, it is better than lucerne. Like lucerne it is best suited to deep, well drained soils. Lotus forage contains condensed tannins that help prevent bloat in livestock. Research is also pointing to other nutritional and animal health advantages from condensed tannins. While its taproot is not as long as that of lucerne, it is more branched and the roots are more extensive in the topsoil. They are species of indeterminate flowering, high dehiscence of the sheath, low survival of the stand of the plant, and the practical difficulties in the management of farming make it difficult to give generalizations and standard recommendations to the management of these forage species (Farey and Smith, 1999).

The potential seed yield estimated in Lotus is 1200 kg ha⁻¹; the average yields got to a worldwide level are below 200 kg ha⁻¹. In the USA, the average yields are between 50 and 170 kg ha⁻¹, in Uruguay the average yields are between 120 and 150 kg ha⁻¹, and in Argentina the average yields are between 25 and 150 kg ha⁻¹ (Fairey and Smith, 1999). In the highlands of Ethiopia two lotus species, viz, Lotus corniculatus (birds-foot trefoil) and Lotus uliginosus (big trefoil) were established using seeds and stem cuttings and evaluated for their seed yield performance (Table 7). The result revealed that the species established by seed comparatively gave better average seed yield at Holetta (18.2 kg ha⁻¹) compared to Ginchi which gave 15.8 kg ha⁻¹. But the species established by stem cuttings gave higher mean seed yield at Ginchi (11.7 kg ha⁻¹) than Holetta (5.5 kg ha⁻¹). The establishment methods over locations have a tremendous effect on seed
yield of lotus species owing to climatic and soil variations of the testing sites. Generally, lotus species established from seeds gave 97.7% more seed yield compared to the species established from stem cuttings. When compared to the two lotus species, *Lotus corniculatus* has relatively higher responses in terms of seed productivity over locations and establishment methods.

<table>
<thead>
<tr>
<th>Species</th>
<th>Established by seed (Holetta) Mean</th>
<th>Established by seed (Ginchi) Mean</th>
<th>Established by cutting (Holetta) Mean</th>
<th>Established by cutting (Ginchi) Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILCA-5976</td>
<td>63.3</td>
<td>15.6</td>
<td>10.6</td>
<td>22.2</td>
</tr>
<tr>
<td>ILCA-7086</td>
<td>1.0</td>
<td>5.6</td>
<td>3.3</td>
<td>-</td>
</tr>
<tr>
<td>AG-S4</td>
<td>1.8</td>
<td>9.0</td>
<td>5.4</td>
<td>0.8</td>
</tr>
<tr>
<td>Diploid 2x</td>
<td>6.6</td>
<td>33.3</td>
<td>20.0</td>
<td>9.3</td>
</tr>
<tr>
<td>Mean</td>
<td>18.2</td>
<td>15.8</td>
<td>17.0</td>
<td>5.5</td>
</tr>
</tbody>
</table>

*Species 1=Lotus corniculatus, Species 2-4= Lotus uliginosus*

### Highland browse forage legumes

#### Tagasaste seed treatment methods

About 240 tagasaste accessions were introduced from ILRI and tested for varietal differences on forage and seed productivity at Holetta. At initial screening, about 74 accessions were selected at seedling level based on establishment performance. Each selected accessions was transplanted at the field at about 100 m apart to control cross pollination and hence performance evaluation and seed multiplication were assessed for more than 6 years. Out of 74 accessions only 28 accessions produced flowers and set seed at Holetta. Tagasaste can be established from transplanting of seedlings, through direct seeding and sometimes from stem cuttings. Preliminary observations on tagasaste establishment methods at Holetta showed higher percentage from transplanting of seedlings (>80%) than direct seeding (10-25%) and stem cuttings (<3%). Direct seeding is cheaper and appropriate means of establishment tagasaste in the highland farming system of Ethiopia. However, in cold relatively wet soil and sever weed competition conditions, transplanting seedlings is beneficial than direct seeding. Tagasaste produce high amount of quality seed in the highlands of Ethiopia. At Holetta, it produces 200 to 300 g of mature seeds per tree per year. Tagasaste seeds have hard seed coat which is
impermeable and needs treatment for successful establishment. At Holetta, observation indicates that untreated seeds gave negligible germination while boiling water treatment for about 7 minutes enhanced germination (Table 8).

Table 8. Tagasaste seeds germination (%) at different length of seed treating times using boiling water and oven at 85°C.

<table>
<thead>
<tr>
<th>Length of treating time</th>
<th>Media</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soil (field)</td>
<td>Bloating paper (Laboratory)</td>
</tr>
<tr>
<td><strong>a) Boiling water (Minutes)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-5</td>
<td>48.8</td>
<td>68.8</td>
</tr>
<tr>
<td>7-11</td>
<td>45.3</td>
<td>75.2</td>
</tr>
<tr>
<td>13-15</td>
<td>37.5</td>
<td>65.3</td>
</tr>
<tr>
<td>20-30</td>
<td>28.5</td>
<td>42.0</td>
</tr>
<tr>
<td>Control</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Mean</td>
<td>32.4</td>
<td>50.6</td>
</tr>
<tr>
<td><strong>b) Oven at 85 °C (Hours)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>40.0</td>
<td>49.5</td>
</tr>
<tr>
<td>2</td>
<td>40.0</td>
<td>45.5</td>
</tr>
<tr>
<td>3</td>
<td>29.0</td>
<td>44.0</td>
</tr>
<tr>
<td>4</td>
<td>36.0</td>
<td>33.0</td>
</tr>
<tr>
<td>Control</td>
<td>2.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Mean</td>
<td>29.4</td>
<td>34.5</td>
</tr>
</tbody>
</table>

For successful establishment of tagasaste, seeds should be properly treated. Seeds with hard coats can be treated by use of chemicals, heat (dry or wet) and mechanical treatment but under Ethiopia condition, chemical treatments are not feasible and not appropriate, however, dry heat, wet heat and mechanical treatments could be cheaper and easy to practice (Getnet, 1998). While treating seed with these methods (Table 8), precise and optimum treating procedures should be established to attain the desired establishment.

Treating tagasaste seed using boiling water for 7-11 minutes showed enormous increment in seed germination over the control (Table 8). Tagasaste seed germination percentage showed a decreasing trend with delayed treating length using oven at 85°C. Accordingly, the highest seed germination was recorded at 1 hours treating length Generally, the result indicated that higher mean seed germination was observed by using boiling water treatment (41.6%) compared to oven dry at 85°C (32.0%). Therefore, using boiling water treatment for 7-11
minutes is suitable for users to break the dormancy of tagasaste seed to enhance its germination.

Conclusions and the Way Forward

Seed production of perennial forage crops requires an intensive management skills and generally low in productivity. Application of appropriate agronomic and processing practice can improve the quantity and quality of seed produced. Clearing dates, clearing methods, age (years) at harvest, harvesting stage after full flowering, manure and inorganic fertilizers application summarized in this paper supports the need for intensive management. Seed productivity of perennial grasses is very low and usually requires more intensive management, and especially very critical in cooler highlands. Grass seed productivity is less responsive to fertilizer application unlike the herbage and stubble yields. Planting materials for vegetatively propagated forages like stem cuttings, root splits and shoot tips of napier grass vary across agro-ecologies. Stem cuttings are suitable in warmer areas whereas root splits and shoot tips in cold and wet conditions for successful establishment. Seed production from lotus is extremely low, nevertheless, it can be multiplied vegetatively by stem cuttings or root splits. For successful establishment of tagasaste seeds should be treated with boiling water for about 7-11 minutes. Generally, all forage crops respond dramatically to good management practices. Higher yields, better forage quality, and improved persistence results from paying attention to the basics of good forage management.

Seed demand of improved forage crops is increasing in alarming rate in the country. However, the supply is very limited and not sustainable which is the major bottleneck to promote the livestock sub sector. The major seed supply methods are the formal and informal seed supply systems. However, the formal seed supply system is very limited and little attention is given to the forage seed production. The informal seed supply system through integrated community based seed supply system with the support of government and non-government organizations could be a more sustainable and reliable alternative; hence, it should be strengthened. Moreover, forage seed related research works are very limited in the country and the generated technologies are not compiled and accessible to attract the producers. Therefore, emphasis should be given to seed related research works at various agro ecological zones and the different stakeholders should be involved to alleviate the forage seed shortage problems of the country. Identification of appropriate seed multiplication sites, small scale private seed production modalities, seed cleaning, processing and storage, and efficient marketing systems should be given due attention in a very near future for successful and sustainable forage seeds for users.
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Getnet Assefa, Abreham Gebeyehu, Fekede Feyissa and Tadesse Tekletsadik. 2004. Effect of methods and dates of clearing regrowths of Rhodes (Chloris gayana) and...


Achievements and Directions of Forage Seed Research and Production in the Highlands of Arsi

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Introduction

Slow adoption rates of forages by farmers, scarcity of varieties of well-adapted forage species, shortage of seeds of highly demanded forage crops and limitations of technical information about forage seed production remain major bottlenecks for improvement of feed quantity and quality in Ethiopia. The number of registered varieties is limited for forage and pasture species and seed productivity and seed crop management techniques for optimum seed yield of the available varieties is rarely documented (CVR, 2010). The demand for improved forage and pasture species is increasing in response to diminishing areas of grazing land. As a result, demand for forage seeds is increasing. Some of the most commonly requested species include fodder beet (Beta vulgaris), alfalfa (Medicago sativa), vetches (Vicia spp.), Rhodes grass (Chloris gayana), colored guinea grass (Panicum coloratum) and oats (Avena sativa). However, availability of seed of these species in Ethiopia is limited, which constrains their utilization. There is need to give special attention to forage seed research and production to improve the supply of quality seeds. Forage seed production requires knowledge and skills on site selection, seed crop establishment, management, seed harvesting and post-harvest handling to ensure seed quality. Information is limited on such issues and available research results on forage seed production in Ethiopia have not been well documented.

At Kulumsa, forage and pasture research has been an integral component of research activities since the late 1960s. Several accessions have been evaluated and recommended by the Chilalo Agricultural Development Unit (CADU, 1973). The commonly recognized forage and pasture species named above have been evaluated for their herbage productivity in several locations. While the focus of the research during the early period was on higher herbage yield and feed value, CADU also started forage seed production and research in the early 1970s. Research covered seed crop establishment, management, seed harvesting and post-harvest management of forage and pasture species but was discontinued in the late 1980s.
Current research activities have focused on variety evaluation for seed and herbage yield, seed crop management and post-harvest handling on alfalfa, vetches, fodder beet, tall fescue (*Festuca arundinacea*), harding grass (*Phalaris aquatica*) and oats. The improvement of forage seed supply has been given priority in forage research and development at Kulumsa. However, research on forage seed production and post-harvest handling is still limited. This paper highlights some findings from past efforts, identifies gaps, and suggests future research directions on forage seed production in the country.

**Micro-Seed Increase and Distribution**

Forage seed production and distribution is an integral component of the forage and pasture research activities at Kulumsa Agricultural Research Center. In 2006/2007, about 366 kg of initial seed was produced and about 45% of it was distributed during the budget year to Agricultural Universities, Research Centers, Farmers, Non-Governmental Organizations and Bureau of Agriculture and Rural Development throughout Ethiopia (Table 1). Seed productivity ranged from 55 kg/ha in Harding grass to 4408 kg/ha in *Avena sativa*. In 2007/2008 a total of 4.25 ha of lands were devoted to micro seed increase and a total of 3154 kg seed was produced (Table 2). More than 80% of the seed produced in the same year was distributed to support forage research and development. The largest area was allocated for oats (*Avena sativa*) production in both years.

**Seed Production Performance of Different forage and Pasture Crops**

Seed production performance is generally affected by seed crop management, environment, and genotype. Seed yield of some promising forage crops such as alfalfa, oats, vetches, tall fescue, harding grass and Rhodes grass was evaluated over several years at Kulumsa. Alfalfa varieties showed significant variation in their seed yield performance at Kulumsa (Table 3). There was also variation in seed yield of varieties across seasons. Alfalfa variety (F-L-77) gave the highest seed yield during the Belg and Meher seasons of 2005 while the highest seed yield during the establishment season (Meher 2004) recorded for variety Sequel.
Table 1. Seed production and distribution status for the year 2006/2007 cropping season at Kulumsa

<table>
<thead>
<tr>
<th>Species</th>
<th>Actual seed yield (kg)</th>
<th>Productivity (kg ha⁻¹)</th>
<th>Distributed (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Phalaris aquatica</em></td>
<td>2.04</td>
<td>55.2</td>
<td>1.05</td>
</tr>
<tr>
<td><em>Chloris gayana</em></td>
<td>5.70</td>
<td>154.4</td>
<td>1.81</td>
</tr>
<tr>
<td><em>Festuca arundinacea</em></td>
<td>8.37</td>
<td>353.5</td>
<td>10.23</td>
</tr>
<tr>
<td><em>Beta vulgaris</em></td>
<td>7.00</td>
<td>310.0</td>
<td>17.63</td>
</tr>
<tr>
<td><em>Avena sativa</em></td>
<td>281.00</td>
<td>4407.8</td>
<td>117.67</td>
</tr>
<tr>
<td><em>Vicia Spp</em></td>
<td>51.00</td>
<td>425.0</td>
<td>12.12</td>
</tr>
<tr>
<td><em>Chamaecytisus palmensis</em></td>
<td>11.00</td>
<td>2750.0</td>
<td>3.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>366.11</strong></td>
<td><strong>1181.0</strong></td>
<td><strong>163.51</strong></td>
</tr>
</tbody>
</table>


Table 2. Seed production and distribution status for the year 2007/2008 cropping season at Kulumsa

<table>
<thead>
<tr>
<th>Species</th>
<th>Actual seed yield (kg)</th>
<th>Productivity (kg ha⁻¹)</th>
<th>Distributed (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Phalaris aquatica</em></td>
<td>2.0</td>
<td>100.0</td>
<td>4.0</td>
</tr>
<tr>
<td><em>Chloris gayana</em></td>
<td>20.9</td>
<td>1045.0</td>
<td>6.5</td>
</tr>
<tr>
<td><em>Festuca arundinacea</em></td>
<td>1.7</td>
<td>85.0</td>
<td>0.1</td>
</tr>
<tr>
<td><em>Melilotus spp</em></td>
<td>18.3</td>
<td>381.5</td>
<td>0.1</td>
</tr>
<tr>
<td><em>Beta vulgaris</em></td>
<td>80.0</td>
<td>276.7</td>
<td>3.6</td>
</tr>
<tr>
<td><em>Avena sativa</em></td>
<td>2454.0</td>
<td>1090.6</td>
<td>2,464.6</td>
</tr>
<tr>
<td><em>Vicia spp</em></td>
<td>565.0</td>
<td>390.6</td>
<td>52.2</td>
</tr>
<tr>
<td><em>Lotus corniculatus</em></td>
<td>2.0</td>
<td>160.0</td>
<td>0.0</td>
</tr>
<tr>
<td><em>Trifolium repense</em></td>
<td>4.0</td>
<td>200.0</td>
<td>0.0</td>
</tr>
<tr>
<td><em>Chamaecytisus palmensis</em></td>
<td>6.0</td>
<td>1500.0</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3153.9</strong></td>
<td><strong>742.1</strong></td>
<td><strong>2532.1</strong></td>
</tr>
</tbody>
</table>


Seed yield of all varieties in the Meher season of 2005 was inferior compared to the Belg season of the same year. This could be attributed to an age effect and the amount of moisture available for seed development. Another study on seed production performance of alfalfa genotypes obtained from the International Livestock Research Institute (ILRI) has shown that there is considerable variation among genotypes in seed yield and seed yield components at Kulumsa (Table 4).
Seed yield ranged from 218.4 to 1160.3 kg/ha with highest seed yield obtained from genotypes with accession numbers ILRI7369 and ILRI9235. Thousand seed weight of genotypes with superior seed yield was smaller than that of other accessions. The two genotypes also gave the highest herbage dry matter yields of 18755.4 and 18885.0 kg/ha, respectively (KARC, 2007).

Seed production performance of temperate forage species such as harding grass (*Phalaris aquatica*) and tall fescue (*Festuca arundinacea*) were evaluated for two years over three locations (Bekoji, Kulumsa, Kofele) in the highlands of Arsi. Results showed that better seed yield was obtained at Kofele, a humid highland, for both species (Table 5). Seed yield of the two temperate grasses was significantly lower during the second year of establishment at all locations with very low yields for harding grass at Bekoji and Kulumsa. This might be attributed to the higher water requirement of the species.

### Table 3. Seed yield performance of alfalfa varieties over three growing seasons at Kulumsa

<table>
<thead>
<tr>
<th>Variety</th>
<th>Meher 2004</th>
<th>Belg 2005</th>
<th>Meher 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-L-77</td>
<td>307.7</td>
<td>458.3</td>
<td>237.3</td>
</tr>
<tr>
<td>Hairy Peruvian</td>
<td>232.0</td>
<td>438.3</td>
<td>177.7</td>
</tr>
<tr>
<td>Hunter River</td>
<td>215.7</td>
<td>216.7</td>
<td>93.0</td>
</tr>
<tr>
<td>Pioneer</td>
<td>89.3</td>
<td>213.7</td>
<td>170.7</td>
</tr>
<tr>
<td>Sequal</td>
<td>324.0</td>
<td>371.7</td>
<td>148.3</td>
</tr>
<tr>
<td>LSD</td>
<td>169.5</td>
<td>217.9</td>
<td>192.1</td>
</tr>
</tbody>
</table>


### Table 4. Seed yield and thousand seed weight of alfalfa genotypes evaluated during the Belg season of 2007 at Kulumsa

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Seed yield (kg/ha)</th>
<th>Thousand seed weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILRI 5681</td>
<td>364.3</td>
<td>2.4</td>
</tr>
<tr>
<td>ILRI 5682</td>
<td>402.6</td>
<td>2.3</td>
</tr>
<tr>
<td>ILRI 7110</td>
<td>218.4</td>
<td>2.4</td>
</tr>
<tr>
<td>ILRI 7323</td>
<td>335.4</td>
<td>2.3</td>
</tr>
<tr>
<td>ILRI 7369</td>
<td>1160.3</td>
<td>2.1</td>
</tr>
<tr>
<td>ILRI 9235</td>
<td>497.7</td>
<td>2.1</td>
</tr>
<tr>
<td>Mean</td>
<td>496.4</td>
<td>2.3</td>
</tr>
<tr>
<td>RMSE</td>
<td>75.33</td>
<td>0.13</td>
</tr>
<tr>
<td>CV</td>
<td>15.17</td>
<td>5.75</td>
</tr>
</tbody>
</table>
Table 5. Seed yield performance of harding grass (*Phalaris aquatica*) and tall fescue (*Festuca arundinacea*) over different locations and years

<table>
<thead>
<tr>
<th>Temperate grass</th>
<th>Year</th>
<th>Seed yield (kg/ha)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bekoji</td>
<td>Kulumsa</td>
</tr>
<tr>
<td><em>Phalaris aquatica</em> var. Sirosa</td>
<td>2007</td>
<td>418.4</td>
<td>207.5</td>
</tr>
<tr>
<td><em>Festuca arundinacea</em> var Demeter</td>
<td>2007</td>
<td>789.9</td>
<td>455.7</td>
</tr>
<tr>
<td>CV% <em>(α=0.05)</em></td>
<td></td>
<td>9.1</td>
<td>8.6</td>
</tr>
<tr>
<td><em>Phalaris aquatica</em> var. Sirosa</td>
<td>2008</td>
<td>14.9</td>
<td>4.2</td>
</tr>
<tr>
<td><em>Festuca arundinacea</em> var Demeter</td>
<td>2008</td>
<td>146.9</td>
<td>200.6</td>
</tr>
<tr>
<td>CV% <em>(α=0.05)</em></td>
<td></td>
<td>11.5</td>
<td>12.4</td>
</tr>
</tbody>
</table>

*Source: KARC, 2007.*

Forage seed production under prevailing crop culture

The crop-livestock farming system in the highlands of Arsi is part of the national cereal belt with 73% of its cultivated area allotted to cereal production (CSA, 2009). Accordingly, the major share of the livestock feed supply is crop residues. Land shortage is often cited by farmers as a major bottleneck for improved forage production. To integrate forage seed production into the existing cropping system, wheat/alfalfa companion cropping was evaluated. Results showed that alfalfa could be successfully established in companion with dwarf and early type wheat cultivars such as KBG-01(Figure 1). Highest alfalfa seed yield from mixed stands was obtained at 60cm row spacing. According to Marble (1989), Alfalfa seed fields have been successfully established when planted with wheat at 75cm row spacing in the Middle East. The fields were maintained as wheat field until wheat was harvested and then as alfalfa seed fields until December. It is important to note that growing wheat with alfalfa did not affect wheat grain yield and rather tended to increase total farm returns (Figure 2). There are important factors to consider in selecting and managing wheat as a companion crop including selecting earlier maturing and shorter-stature varieties, reducing the seeding rate and promptly removing straw.
In general, forage plants are believed to be heavy feeders and thus drain a considerable amount of nutrients (Hazra and Sinha, 1996). In grasses, the aim of fertilizing seed crops is to synchronize production of a large number of fertile heads to get uniform ripening. Application of nitrogen to grass seed crops is nearly always profitable since it promotes tiller fertility (% tillers producing inflorescence) and ultimately good seed yield. Increasing fertilizer rate up to 200 kg ha\(^{-1}\) of urea resulted in a rapid increase in seed yield of Rhodes grass at the
first harvest at Kulumsa (Figure 3). Further increase in rate of urea application did not result in considerable improvement in seed yield. In the older stands, seed yield was lower than that of the first harvest but increasing fertilizer rate up to 300kg ha\(^{-1}\) improved seed yield by more than 200% as compared to the unfertilized plots. After the first harvest, seed crops require a substantial amount of N-fertilizer since nitrogen is essential for formation of many seed heads and fertile spikelet’s and better synchronization. Determination of the proper time of fertilizer top dressing is an important step in fertilizer management for seed crops. Time of urea top-dressing was studied on Rhodes grass and it was observed that top-dressing the seed crop in mid-July gave the highest amount of clean and pure germinating seed (Figure 4). Urea top-dressing later than mid-July continuously decreased both yield and quality of seed. However, urea application at any time improved both seed production parameters.

![Figure 3. Effect of rate of urea fertilizer on seed yield of Rhodes grass in stands at different ages after establishment at Kulumsa (ARDU, 1983)](image)

![Figure 4. Effect of time of urea top-dressing on clean seed yield (SY) and pure germinating seed yield (PGS) of Rhodes grass at Kulumsa (CADU, 1973)](image)
Harvesting forage seed

Forage seed harvesting is complicated by poor synchronization of flowering/heading, seed shattering and the difficulty in attaining maximum viability at harvest. Uneven heading, seed setting, and ripening of grass seeds make the determination of harvesting time difficult. Seed harvesting in tropical grasses is usually carried out some 6-7 weeks after initial head emergence (5-10 heads per plant). In Rhodes grass, pure germinating seed yield (PGS) increased until two weeks after the first heads started to shatter (Figure 5). High clean seed yields (more that 200 kg ha\(^{-1}\)) were obtained by harvesting Rhodes grass between one and four weeks after the first heads start shattering. Maximum clean seed yield of colored guinea grass was obtained by harvesting two weeks later. The highest pure germinating seed yield was obtained after five weeks in colored guinea grass.

![Figure 5. Effect of harvesting time on seed yield of Rhodes grass and colored guinea grass (CADU, 1973) where, CGSY and CGPGS=Colored guinea grass clean seed and pure germinating seed yields; RSY and RPGS= Rhodes grass clean seed and pure germinating seed yields.](image)

Effect of storage period and seed treatment on seed quality

Effects of adverse storage conditions on the seed vigor of various crop species have been well documented (Hopkinson & English, 2005). When stored under ambient temperature and humidity conditions, seeds of many plant species lose viability and vigor within a short period except for legume seeds with impermeable seed coats (Čupić et al., 2005). Vigor loss is associated with
biochemical losses associated with seed ageing (Murthy et al., 2003). Seed vigor enhancement techniques such as hydro priming are used to improve the germination and vigor of seeds (Harris, 1996). Hydro priming is reported to improve seed and seedling performance in soybean (Mohammad, 2009).

Speed of germination of unprimed seeds was not affected by storing seeds for up to two years under ambient conditions whereas emergence index increased as seed storage duration was increased up to two years (Figure 6). Hydro priming significantly improved speed of germination at all durations of storage. Emergence index was also improved by hydro-priming common vetch seeds at zero and one year period of storage. These results are in line with that of Mohammad (2009), who reported that hydro priming significantly improved speed of germination in soybean seed. The faster rate of germination of hydro-primed seeds could be attributed to enhanced repair in the intra-cellular architecture and mobilization of hydrolytic enzymes required for visible germination to occur (Bewley, 1997).

![Figure 6. Speed of germination and seedling emergence index of common vetch seeds as affected by duration of storage and hydro-priming.](image)

Data consists of means ±SE. Data points followed by different letters are significantly different at \( \alpha = 0.05 \) (Source: Karta et al., 2011)
Problems in Forage Seed Production and Research

Problems in forage seed production in Ethiopia include:

- Limited number of varieties commercially registered;
- Shortage of locally relevant technical information on establishment, seed crop management, seed harvesting, cleaning, packaging and storage;
- Poor seed yielding ability, seed shattering and dormancy of forages;
- Unpredictable demand for forage seed, low priority by farmers for cultivated forage and weak forage seed marketing;
- Very limited attention given to forage seed production by the Ethiopian Seed Enterprise; and
- Inadequate forage development efforts by the extension system

In order to resolve some of these problems attention should be given to:

- Research in herbage productivity and quality improvement;
- Improving skills in forage breeding, agronomic management of seed crops for seed yield and quality improvement;
- Improving facilities for post-harvest handling and research; and
- Training personnel in the area of forage seed research

Directions in Forage Seed Production and Research

Future activities that could be undertaken to support forage seed production and strengthen the forage seed value chain and networking include:

Forage crop improvement
- Data collection should consider traits associated with optimum seed yield and quality, but without significantly affecting herbage yield and quality; and
- Focus should be on a limited number of species with wide adaptation for seed as well as herbage production

Forage seed agronomy
- Information on seed crop establishment (seed rate, fertilizer rate, dormancy, seed establishment) should be generated for species with wider adaptation and superior herbage yield and quality; and
- Seed crop management (stand management for perennials, harvesting stages and harvesting methods) should be improved

Post harvest handling
- Seed cleaning and packaging techniques, storage regime, duration of storage, dormancy breaking treatments, seed enhancement should be improved
Conclusion and Recommendations

Although general information is available on forage seed crop establishment and management, seed harvesting and post harvest handling, there remains a knowledge gap on seed production and post harvest handling for forage species in Ethiopia. Several bottlenecks exist in the area of forage seed production and research in Ethiopia and action is needed to improve the forage seed production and research system in the country.

References

Karta Kaske, R.P.S. Tomer, and Bekele Abebie. 2011. Effects of duration of storage and hydro-priming on seed germination and vigor of common vetch. Journal of Science and Development, 1:
Forage Seed Research and Development in Irrigated Areas

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Introduction

Werer Research Center began research in irrigated forage crops in the mid 1960s. Although the majority of the studies on forage variety development focused on evaluations of forage yield and adaptability, seed yield was also considered for selected species. To that end, some specific experiments on forage seed production started during the late 1960s. Most of the experiments on forage and forage seeds addressed issues of variety development for irrigated areas of the Afar region to generate packages of technologies for irrigated forage (Table 1).

Table 1. Issues addressed in forage seed research at WARC during 1966 – 1989

<table>
<thead>
<tr>
<th>Issues addressed in forage seed research</th>
<th>Forage crops studied</th>
<th>Major parameters evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety trials</td>
<td>Different forage varieties</td>
<td>Adaptability, DM and seed yield</td>
</tr>
<tr>
<td>Mixed forage crops development</td>
<td><em>Medicago sativa</em> with different grasses</td>
<td>Compatibility, DM and seed yield</td>
</tr>
<tr>
<td>Seed rate</td>
<td>Different forage varieties</td>
<td>DM and seed yield</td>
</tr>
<tr>
<td>Irrigation requirement</td>
<td><em>Medicago sativa</em> c.v. Hairy Peruvian</td>
<td>DM and seed yield</td>
</tr>
<tr>
<td>Production cost</td>
<td><em>Medicago sativa</em> c.v. Hairy Peruvian</td>
<td>Seed yield</td>
</tr>
</tbody>
</table>


Forage Seed Research and Development before the Year 2000

Evaluation of grass species

Several grass variety trials were done at WARC. Almost all of the forage species for these trials were introduced from foreign countries like Pakistan, USA, and Australia. In 1973, 51 different grass species were established at the center with the objectives of evaluating the performance of the species under irrigation; to
collect and maintain seeds of the promising grasses for subsequent research on seed and forage production; and to recommend and extend the promising grass species and varieties to similar environments elsewhere in Ethiopia. Reports on forage research at the center indicated that most of the species were well adapted to the area. Some of the species gave substantial forage dry matter and seed yields (Table 2). However, only very few of these species are currently available in the center. A brief description on the performance of some selected species at WARC is given below:

*Cenchrus ciliaris (African Foxtail):* This species showed an excellent performance at WARC during the evaluation period. It was established easily, grew fast, and gave a substantial amount of forage. There is a need to increase seed production of the species under irrigation for further research and development activities.

*Chloris gayana (Rhodes grass):* Although the establishment and growth of Rhodes grass was slow compared to other grass species, its herbage yield was very attractive. Evaluation of management techniques for increased seed production of this grass under irrigation has been a worthwhile endeavor.

*Panicum antidotale (Blue panic):* According to the 1966 – 1983 progress report of WARC, seeds of *Panicum antidotale* were sown on 1/20 of a hectare plot at the rate of 4.6 kg/ha on March 28, 1973. Slow growth of this particular grass was observed. However, seed yield was 550 kg/ha from the first harvest made on September 4, 1973, while dry matter herbage production was 6.4 t/ha.

*Panicum coloratum (Makarikari grass):* On March 28, 1973, 1/20 of a hectare plot was sown using a seeding rate of 4.6 kg/ha for seed production (WARC, progress report, 1966 - 1989). The first harvest was made on September 11, 1973 and seed yield was 50 kg/ha.

*Panicum maximum (Guinea grass):* Several varieties of guinea grass were evaluated at WARC. Almost all of the varieties adapted and performed well. However, *Panicum maximum* accession 402 showed the best performance with good leaf/stem ratio and seed yield.

*Paspalum dilatatum (Dallis grass):* Dallis grass also showed good performance at WARC. Different varieties of *Paspalum spp.* have been observed in some regions of Ethiopia and promotion and scale up of this species could have been successful.
**Setaria sphacelata** *(Setaria)*: This is a tufted perennial grass native to tropical Africa and used for silage, hay, and grazing. At WARC, this grass showed good performance.

<table>
<thead>
<tr>
<th>Accession</th>
<th>Grass species</th>
<th>Seed (kg/ha)</th>
<th>Herbage (DM t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAR-735</td>
<td><em>Bouteloua gracilis</em></td>
<td>189</td>
<td>6.6</td>
</tr>
<tr>
<td>IAR-1863</td>
<td><em>Cenchrus ciliaris</em></td>
<td>438</td>
<td>12.0</td>
</tr>
<tr>
<td>IAR-1864</td>
<td><em>Cenchrus ciliaris</em></td>
<td>273</td>
<td>7.0</td>
</tr>
<tr>
<td>IAR-1191</td>
<td><em>Panicum antidotale</em></td>
<td>1500</td>
<td>18.3</td>
</tr>
<tr>
<td>IAR-465</td>
<td><em>Panicum coloratum</em></td>
<td>184</td>
<td>28.2</td>
</tr>
<tr>
<td>IAR-1871</td>
<td><em>Panicum maximum str. 402</em></td>
<td>121</td>
<td>22.0</td>
</tr>
<tr>
<td>IAR-1870</td>
<td><em>Panicum maximum</em></td>
<td>277</td>
<td>21.8</td>
</tr>
<tr>
<td>IAR-1703</td>
<td><em>Panicum maximum</em></td>
<td>14</td>
<td>10.8</td>
</tr>
<tr>
<td>IAR-909</td>
<td><em>Panicum maximum</em></td>
<td>15</td>
<td>39.4</td>
</tr>
<tr>
<td>IAR-735</td>
<td><em>Paspalum dilatatum</em></td>
<td>288</td>
<td>11.0</td>
</tr>
<tr>
<td>IAR-1866</td>
<td><em>Paspalum plicatulum</em></td>
<td>530</td>
<td>14.0</td>
</tr>
<tr>
<td>IAR-1194</td>
<td><em>Setaria sphacelata</em></td>
<td>173</td>
<td>12.3</td>
</tr>
</tbody>
</table>

Introduction and evaluation of other species has been conducted for several additional years. However, detailed studies on variety development were not carried out for most of the species that were introduced. The following species were also introduced and evaluated for both forage and seed yield following the completion of the evaluation of the above grass species.

**Sorghum sudanense** *(Sudan grass)*: The total dry matter yield of the Sudan grass varieties ranged from 32 to 49 t/ha. The piper Sudan grass varieties persisted up to eight cuttings with excellent forage yield. In terms of seed production, sweet Sudan grass yielded 26.2 q/ha followed by piper Sudan grass (21.7 q/ha).

**Cynodon dactylon** *(Bermuda grass)*: The performance of this grass was exceptional, with an average yield of 7 t/ha/cutting. This variety out-yielded all of the forage crops tested in that season, but the seed yield was low.

**Andropogon intermedius** *(Medio blue stem)*: Dry matter yield of this grass was impressive (53 t/ha). It also produced a fair amount of seed. The progress report concluded that many of the grass species introduced and tested
were very valuable with high forage and seed yield under irrigation; while some others, although low in yield, may have the potential to be introduced to the surrounding rangeland areas which have low rainfall. In addition, research on seed production is a highly recommended aspect of the forage development at WARC.

**Evaluation of Forage Legumes**

Leguminous forage species were introduced and evaluated at WARC under irrigation. Alfalfa varieties were the most widely studied species in the center (Table 3). The dry matter and seed yield of the varieties was variable and seed yield declined with increasing forage yield although the relationship between forage yield and seed yield was not statistically significant. Currently, the only alfalfa variety available in the center is *Medicago sativa cv. Hairy Peruvian*, which was selected for its higher forage dry matter yield.

<table>
<thead>
<tr>
<th>Variety</th>
<th>DM yield (t/ha)</th>
<th>Seed yield (kg/ha)</th>
<th>Variety</th>
<th>DM yield (t/ha)</th>
<th>Seed yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haymor</td>
<td>4.5</td>
<td>300</td>
<td>Springfield</td>
<td>2.5</td>
<td>200</td>
</tr>
<tr>
<td>Hunter river</td>
<td>3.3</td>
<td>100</td>
<td>Trifectal</td>
<td>2.6</td>
<td>200</td>
</tr>
<tr>
<td>Hunter field</td>
<td>2.5</td>
<td>500</td>
<td>Vela</td>
<td>1.9</td>
<td>11</td>
</tr>
<tr>
<td>Kohli</td>
<td>2.6</td>
<td>100</td>
<td>Victoria</td>
<td>3.5</td>
<td>33.3</td>
</tr>
<tr>
<td>Moapa</td>
<td>3.7</td>
<td>166.7</td>
<td>Wakefield</td>
<td>2.7</td>
<td>566.7</td>
</tr>
<tr>
<td>Perscot</td>
<td>2.9</td>
<td>66.7</td>
<td>WL 318</td>
<td>2.0</td>
<td>133.3</td>
</tr>
<tr>
<td>Segual</td>
<td>3.3</td>
<td>66.7</td>
<td>WL 514</td>
<td>2.1</td>
<td>100</td>
</tr>
<tr>
<td>Sheffield</td>
<td>3.0</td>
<td>633.3</td>
<td>WL 515</td>
<td>5.5</td>
<td>33.3</td>
</tr>
<tr>
<td>Silver</td>
<td>2.9</td>
<td>400</td>
<td>WL 516</td>
<td>3.1</td>
<td>100</td>
</tr>
</tbody>
</table>

**Evaluation of Fodder Trees**

Among the fodder trees/shrub species, *Gliricidia, Leucaena* and *Sesbania* were the most widely studied species under irrigation at WARC (WARC: Progress Report, 1966 - 1989). However, only four species of *Sesbania* were studied for both forage and seed production. Some of the species gave more than 600 kg/ha of seed yield in a season, while others were low producers (Table 4).
Table 4. Seed yield of different Sesbania species under irrigation at Werer

<table>
<thead>
<tr>
<th>Species</th>
<th>ILCA No.</th>
<th>Seed yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sesbania rostrata</td>
<td>6952</td>
<td>635.0</td>
</tr>
<tr>
<td>Sesbania rostrata</td>
<td>9266</td>
<td>171.9</td>
</tr>
<tr>
<td>Sesbania sesban</td>
<td>10375</td>
<td>504.0</td>
</tr>
<tr>
<td>Sesbania sp.</td>
<td>*</td>
<td>522.9</td>
</tr>
<tr>
<td>Sesbania sesban</td>
<td>10639</td>
<td>25.0</td>
</tr>
<tr>
<td>Sesbania sesban</td>
<td>10865</td>
<td>100.0</td>
</tr>
<tr>
<td>Sesbania grandiflora</td>
<td>9265</td>
<td>*</td>
</tr>
</tbody>
</table>

*Record was missing

Grass-Legume Mixed Crops

Compatibility of different forage species in grass/legume mixtures was assessed with the objectives to increase forage yield on the limited/scarcely cultivable land area, while improving land fertility. The studies assessed the seed production potential of selected forage species under mixed forage cropping systems. Alfalfa was the preferred leguminous forage selected for mixed cropping with grass species (WARC, Progress Report, 1966 - 1989). This could be due to its easy establishment and substantial forage yield in a mixed cropping system under irrigation. Alfalfa performed well in terms of both forage and seed yield in a mixed cropping system under irrigation (Table 5).

Table 5. Forage DM and seed yield of Alfalfa-grass mixtures at Werer Research Center

<table>
<thead>
<tr>
<th>Mixture - Alfalfa with</th>
<th>Forage mixture DM (t/ha)</th>
<th>Alfalfa seed yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cenchrus ciliaris</td>
<td>104</td>
<td>380</td>
</tr>
<tr>
<td>Panicum coloratum</td>
<td>106</td>
<td>56</td>
</tr>
<tr>
<td>Panicum antidotale</td>
<td>108</td>
<td>315</td>
</tr>
</tbody>
</table>

Seed Rate Trials

Seed rate experiments or trials were conducted to determine the optimum seeding rate for improved forage and seed yield of forage species/varieties. Some of the species/varieties gave relatively higher seed and forage yields with
lower seed rates. For example, *Chloris gayana* gave 265 kg/ha of seed when sown with a seed rate of 3 kg/ha. However, forage yield was much higher when sown with higher seed rates of up to 6 kg/ha (Table 6).

Table 6. Average seed and dry matter yield of selected forage species under irrigation

<table>
<thead>
<tr>
<th>Species</th>
<th>Seed rate (kg/ha)</th>
<th>Seed yield (kg/ha)</th>
<th>Total DM (t/ha)</th>
<th>No. of harvests</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Panicum antidotale</em></td>
<td>4.5</td>
<td>729</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td><em>Panicum maximum</em></td>
<td>8.0</td>
<td>275</td>
<td>35.3</td>
<td>4</td>
</tr>
<tr>
<td><em>Panicum coloratum</em></td>
<td>8.0</td>
<td>137</td>
<td>31.1</td>
<td>4</td>
</tr>
<tr>
<td><em>Chloris gayana</em></td>
<td>3.0</td>
<td>265</td>
<td>41.2</td>
<td>4</td>
</tr>
<tr>
<td><em>Sorghum Sudanese</em></td>
<td>10.0</td>
<td>858</td>
<td>9.3</td>
<td>1</td>
</tr>
<tr>
<td><em>Medicago sativa</em></td>
<td>10.0</td>
<td>382</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td><em>Macroptillium atropurpureus</em></td>
<td>25.0</td>
<td>226</td>
<td>5.9</td>
<td>3</td>
</tr>
</tbody>
</table>

Seed rate affects crop stand and seed yield. In a study to determine the optimum seed rate for high seed production in panicum grass and Rhodes grass, it was observed that higher seed yield was obtained from panicum at the lower seed rate, while Rhodes grass gave higher seed yield when sown using a higher seed rate (Table 7). However, seed rate had no clear effect on germination of both grass species. In some conditions, different seed rates were recommended for mixed cropping as compared to that of sole cropping (Table 8).

Table 7. Effects of seed rate on germination and seed yield of *Panicum antidotale* and *Chloris gayana*

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Sowing rate kg/ha</th>
<th>Germination (%)</th>
<th>Seed yield (kg/ha/harvest)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Panicum antidotale</em></td>
<td>4</td>
<td>47.19</td>
<td>372.22</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>59.33</td>
<td>325.00</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>53.78</td>
<td>367.59</td>
</tr>
<tr>
<td><em>Chloris gayana</em></td>
<td>4</td>
<td>19.37</td>
<td>378.70</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>18.93</td>
<td>362.96</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>19.00</td>
<td>397.22</td>
</tr>
</tbody>
</table>
Table 8.  Seed rates used for mixed and sole forage cropping under irrigation

<table>
<thead>
<tr>
<th>Cropping</th>
<th>Herbage DM (t/ha)</th>
<th>Seed rate (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lablab purpureus (Dolichos)</td>
<td>45.3</td>
<td>20</td>
</tr>
<tr>
<td>Dolichos + Maize</td>
<td>28.4</td>
<td>15/30</td>
</tr>
<tr>
<td>Dolichos + Sorghum</td>
<td>38.2</td>
<td>15/20</td>
</tr>
<tr>
<td>Dolichos + Chloris gayana</td>
<td>45.9</td>
<td>15/4</td>
</tr>
<tr>
<td>Sorghum</td>
<td>47.3</td>
<td>30</td>
</tr>
<tr>
<td>Sorghum + Maize</td>
<td>41.3</td>
<td>20/30</td>
</tr>
<tr>
<td>Maize</td>
<td>11.7</td>
<td>40</td>
</tr>
<tr>
<td>Panicum maximum</td>
<td>30.7</td>
<td>8</td>
</tr>
<tr>
<td>P. maximum + Glycine javanica</td>
<td>42.7</td>
<td>5/6</td>
</tr>
<tr>
<td>P. maximum + Medicago sativa</td>
<td>36.2</td>
<td>5/6</td>
</tr>
<tr>
<td>P. maximum + P. atropurpleus</td>
<td>19.1</td>
<td>10/30</td>
</tr>
<tr>
<td>Panicum coloratum</td>
<td>43.4</td>
<td>8</td>
</tr>
<tr>
<td>P. coloratum + P. atropurpleus</td>
<td>24.4</td>
<td>10/30</td>
</tr>
<tr>
<td>Phaseolus atropurpleus</td>
<td>12.3</td>
<td>15</td>
</tr>
<tr>
<td>P. atropurpleus + C. gayana</td>
<td>7.4</td>
<td>4/6</td>
</tr>
<tr>
<td>P. coloratum + M. sativa</td>
<td>24.5</td>
<td>4/6</td>
</tr>
<tr>
<td>C. gayana + M. sativa</td>
<td>24.7</td>
<td>4/10</td>
</tr>
<tr>
<td>Vicia atropurpleus</td>
<td>0.5</td>
<td>40</td>
</tr>
<tr>
<td>Glycine javanica</td>
<td>8.9</td>
<td>8</td>
</tr>
<tr>
<td>Medicago sativa</td>
<td>19.5</td>
<td>10</td>
</tr>
<tr>
<td>Cenchrus ciliaris</td>
<td>18.2</td>
<td>6</td>
</tr>
<tr>
<td>Chloris gayana</td>
<td>42.3</td>
<td>6</td>
</tr>
</tbody>
</table>

With the advance in research and development of forage crops in the irrigated areas, it was necessary to improve availability of planting materials (seeds and cuttings). As a result, specific experiments fully focused on aspects of forage seed production have been gradually apparent in the center. Some of the efforts in this regard are briefly presented below.

**Irrigation Requirement**

Irrigation time, frequency, and amount are the most important factors in irrigated crop production. Irrigating some forage crops may favor vegetative growth (regardless of the forage quality), rather than reproductive development. Optimal
amount of irrigation water ensures the soil’s productivity by maintaining soil pH. It is well known that successive and over irrigation increases the underground water table, which triggers soil salinity. Irrigation studies on alfalfa showed that discontinuing irrigation at 50% flowering resulted in a relatively higher seed yield (Table 9). Three successive irrigations after seed harvest are optimal to support better seed yield (Table 10).

Table 9. Alfalfa seed yield as influenced by time of interruption of irrigation

<table>
<thead>
<tr>
<th>Time of discontinuation of irrigation</th>
<th>Mean seed yield over 2 harvests (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% flowering</td>
<td>80</td>
</tr>
<tr>
<td>50% flowering</td>
<td>112</td>
</tr>
<tr>
<td>100% flowering</td>
<td>102</td>
</tr>
</tbody>
</table>

Table 10. Effect of number of irrigations on mean seed yield of alfalfa (Medicago sativa cv. Hairy Peruvian)

<table>
<thead>
<tr>
<th>Number of irrigations between seed harvests</th>
<th>Seed yield (kg/ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1998</td>
</tr>
<tr>
<td>3</td>
<td>2375</td>
</tr>
<tr>
<td>4</td>
<td>1548</td>
</tr>
<tr>
<td>5</td>
<td>2093</td>
</tr>
</tbody>
</table>

Cost of Seed Production

A study was carried out to assess the cost of alfalfa seed production that was more than five times lower than the net profit excluding the cost for land rent.

Forage Seed Research and Development during the Last Ten Years

The promotion and scaling up of available forage seed technologies has recently been given emphasis. Forage seed production is now considered as a major activity in forage crops research due to increased demand for forage seeds. The research system is informally mandated for the production as well as dissemination of these seeds in the country because of the limited number of
sources for forage seed supply. Some of the efforts being made in forage seed research during the last ten years are summarized in Table 11, and brief discussions are included in the text.

**Variety trials**
Although very few species/varieties are commonly used, emphasis has been given for further introduction and screening adaptation to identify higher yielding forage crops for irrigated areas of the Afar region (WARC: Progress report, 2006 - 2009). Currently, some varieties/accessions are in the final stage of evaluation. Few of these materials have outperformed the accessions currently under production for both DM and seed yield. These include grasses Rhodes grass cultivar Boma Rhodes (acc. no. 13330) and Napier grass (acc. no. 16834) and legumes *Desmodium uncinatum* (acc.no. 6765) and *Clitoria ternatea* (acc.no. 9296).

<table>
<thead>
<tr>
<th>Table 11. Components of forage research efforts during the last 10 years at Werer Agricultural Research Center</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recent issues addressed in forage seed research</strong></td>
</tr>
<tr>
<td>Variety trial</td>
</tr>
<tr>
<td>Harvesting time and seeding rate</td>
</tr>
<tr>
<td>Scaling up forage seed technologies</td>
</tr>
<tr>
<td>Micro seed increase</td>
</tr>
<tr>
<td>Basic seed production</td>
</tr>
</tbody>
</table>

**Harvesting time**
Determining the optimum time of seed harvest is the most important factor for seed production of grass seeds. Studies on harvesting time of *Panicum antidotale* showed that higher seed yield was obtained when harvested 40 days after anthesis. However, germination was relatively lower 40 days than 50 days after anthesis (Table 12). Rhodes grass seed yield was at its maximum when harvested 50 days after anthesis and germination percentage was also relatively better at this stage (Table 12).

| Table 12. Effect of seed harvesting time on germination and seed yield of *Panicum antidotale* and *Chloris gayana* |
### Harvesting time

<table>
<thead>
<tr>
<th>Harvesting time (days after anthesis)</th>
<th>Seed yield (kg/ha/harvest)</th>
<th>Germination %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Panicum</td>
<td>Chloris</td>
</tr>
<tr>
<td>30</td>
<td>368.5</td>
<td>378.7</td>
</tr>
<tr>
<td>40</td>
<td>407.4</td>
<td>318.5</td>
</tr>
<tr>
<td>50</td>
<td>288.9</td>
<td>441.7</td>
</tr>
</tbody>
</table>

### Storage period

Seed viability decreases with increasing time of storage. The viability of seeds of *Panicum antidotale* and *Chloris gayana* was studied under unconditioned storage condition at WARC. The study revealed that the viability of seeds of both grass species declined after one year of storage while maximum germination was observed at 12 months of storage (Table 13).

**Table 13. Effects of storage period on seed viability of *Panicum antidotale* and *Chloris gayana***

<table>
<thead>
<tr>
<th>Duration of storage (months)</th>
<th>Germination (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Panicum antidotale</em></td>
</tr>
<tr>
<td>1</td>
<td>42.96</td>
</tr>
<tr>
<td>3</td>
<td>48.82</td>
</tr>
<tr>
<td>6</td>
<td>45.11</td>
</tr>
<tr>
<td>9</td>
<td>62.89</td>
</tr>
<tr>
<td>12</td>
<td>76.74</td>
</tr>
<tr>
<td>24</td>
<td>44.07</td>
</tr>
</tbody>
</table>

### Micro seed increase

Continuous production and maintenance of breeder and pre basic seeds has been an integral component of the research system for many years because of shortages of forage seeds. Every year, micro seed plots of 10 to 15 selected species are multiplied under irrigation. These are used for research activities for the centre and other research centers and organizations. Similarly sees of few species are multiplied at relatively larger scales as pre basic seeds every year. For example, 3420 kg forage seeds were produced during the year 2010/2011 production season for rhodes grass (901kg), *Panicum antidotale* (1325kg), cenchrus (282kg), alfalfa (47kg), siratro (26kg), lablab (733 kg), *Leucaena leucocephala* (96kg), and *Sesbania sesban* (10 kg). The majority of all these seeds produced were distributed to seed producers and used for forage scaling up activities.
Forage Seed Pricing At WARC

Due to the increase in demand and cost of production, the center has set prices for most common forage crops (Table 14). The seed pricing system also helps to ensure that proper attention is given to management of the seeds by users. This price is still fair and affordable for most stakeholders. However, farmers are not forced to pay for these forage crops for demonstration activities planned by the center.

Table 14. Revised forage seed price (Birr/kg) at Werer Agricultural Research Center (in the year 2011)

<table>
<thead>
<tr>
<th>Forage species</th>
<th>2007</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhodes</td>
<td>50.00</td>
<td>80.00</td>
</tr>
<tr>
<td>Cenchrus</td>
<td>50.00</td>
<td>150.00</td>
</tr>
<tr>
<td>Panicum</td>
<td>60.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Lablab</td>
<td>40.00</td>
<td>60.00</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>100.00</td>
<td>200.00</td>
</tr>
<tr>
<td>Leucaena</td>
<td>30.00</td>
<td>30.00</td>
</tr>
<tr>
<td>Sesbania</td>
<td>20.00</td>
<td>28.00</td>
</tr>
<tr>
<td>Cowpea</td>
<td>30.00</td>
<td>50.00</td>
</tr>
</tbody>
</table>

Challenges

Research challenges
The main challenges in research and development of forage crops in the research system include limited forage varieties for screening and variety development; the need for many species for the wide agro-ecology; variability of interest among users; storage problems and/or lack of storage facilities; and budget limitations.
Production and development challenges
Challenges that impact forage seed production and development can be many and the main ones are the lack of mandate in the sector; high cost and/or limited availability of forage seeds; the variability or inconsistency of seed demand by users; the complexity or difficulty of forage seed production; the unstable/unknown market conditions; and budget limitations for the work in the area.

Different actions can be taken to alleviate the challenges and constraints associated with forage seed research and development both under irrigated and rain-fed conditions. These include work with selected target groups; creation of sustainable market conditions; establishment of cooperatives in forage seed production; development of sufficient forage seed production facilities; continual assessment of demand and supply of forage seeds; and scaling up of the available forage seed technologies

References
Seed Production Potentials of Annual Forage Crops in the Central Highlands of Ethiopia

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Introduction

The production and maintenance of adequate quantities of adapted and promising pure forage seed is fundamental to a progressive national forage development program. However, a number of constraints continue to hamper seed production and distribution from private seed companies including: variable environmental conditions affecting production and variable economic conditions affecting demand. But, there is a strong need to improve the linkages between smallholder seed production and the private seed sector to ensure long term continuity of seed supply. Small/no land allocation for forage seed production, low adoption of improved forage crops production, forage seed unavailability, lack of awareness on forage seed production technology, lack of forage seed infrastructure facilities, lack of enough forage seed producing companies, lack of market for selling of forage seeds, lack of strong emphasis for the sector etc. are some of the major challenges for sustainable supply of forage seeds in the country. However, due to diverse agro-ecologies, many of the temperate and tropical pasture and forage crops that have been tested and grown in Ethiopia have no problem of flowering and seed setting. This provides a good opportunity for the country to establish local seed production in the existing farming system to satisfy the increasing demand of forage seeds.

Though research and development on forage seed production is just beginning in Ethiopia, some preliminary works have been conducted but, the research outputs have not been well documented/published and accessible for various interested users. To make the information’s more accessible, Holetta research center has summarized the past research findings to fill the information gaps regarding to annual forage seed production status in the central highlands. Therefore, the objective of this paper is to review, compile, synthesize and document the past research achievements on seed production of annual forage crops to avail the information to users.
Evaluation of Annual Forage Crops

Agronomic and seed yield potentials of oat varieties

Twenty oat varieties were selected based on their adaptation to the highland agro-ecological zone from earlier screening trials and evaluated for their seed yield and related performance at Holetta. A uniform seeding rate of 100 kg/ha was used for all the varieties as previous recommendation for pure stand of oats in the highlands of Ethiopia. Fertilizer at the rate of 100 kg/ha DAP was applied across all plots at sowing. Seed filling and seed maturity periods, seed yield, thousand seed weight and harvest index of the tested oat varieties are indicated in Table 1. The tested oats varieties showed a significant variation in seed filling and seed maturity periods. Seed filling period (heading to seed maturity) of oats varieties ranged from 64 to 80 days with a mean of 73 days and seed maturity period ranged from 159 to 187 days with a mean of 166 days. High seed producing varieties such as 79 Ab 382 (TX) (80 SA 94), 79 Ab 384 (TX) (80 SA 95), SRCP X 80 Ab 2806, 79 CP 84 (Coker SR res) 80 SA 130, SRCP X 80 Ab 2764, SRCP X 80 Ab 2767 comparatively took shorter seed filling period and vegetative growth stage but longer seed maturity period than most other varieties. Fekede (2004) reported that late maturing oat varieties tended to have comparatively shorter seed filling period and longer vegetative growth period than early maturing varieties.

The seed yield of the oats varieties were significantly different with a range of 3.83 to 10.56 t/ha with an average of 6.76 t/ha (Table 1). Oats varieties such as 79 CP 84 (Coker SR res) 80 SA 130, SRCP X 80 Ab 2767, CP x/SRCP X 80 Ab 2291 and SRCP X 80 Ab 2806 gave significantly higher (P<0.05) seed yield whereas CI-8251, PI-244480 and PI-5800 gave significantly lower (P<0.05) seed yield than most other varieties. Varieties such as C 7512/SRCP X 80 Ab 2252, 79 Ab 384 (TX) (80 SA 95), Kyto W 78394 Canada and 79 Ab 382 (TX) (80 SA 94) also gave considerably higher seed yield. Farmers around Sheno, Sellalie, and many other areas cultivate oats and the seed used for human food, for livestock feed as a concentrate or as dual purposes. Based on survey result in the central highlands of Ethiopia, farmers were looking for seed types of oats, however, the demonstration and popularization of these varieties were not widely spread (Getnet et al., 2003). According to Fekede (2004), 79 CP 84 (Coker SR res) 80 SA 130 gave exceptionally higher seed yield which is greater than the seed yield reported for improved barley and wheat varieties in the area and this variety could thus be a potential candidate to be promoted for seed production in areas where oats are grown for human food. Thousand seed weight of the 20 oats varieties showed significant difference and ranged from 19.48 to 33.58 g with an average weight of 27.36 g (Table 1). Oats varieties are broadly divided into two parts based on the purpose of production and seed yield
performance. They are forage and seed types and the forage type has lower thousand seed weight than the seed type due to lower seed size in the former type. Research findings also showed that most of the oats varieties with high seed yield had higher thousand seed weight (Getnet et al., 2003; Fekede, 2004). 79 CP 84 (Coker SR res) 80 SA 130 was the highest seed producing variety had significantly higher (P<0.05) thousand seed weight whereas lower seed yielding (forage type) varieties such as PI-244480 and CI-8251 had significantly lower (P<0.05) thousand seed weight than most of the other varieties. Harvest index of the tested oats varieties showed a significant variation and ranged widely from 22.0-43.5% with a mean of 35.54% (Table 1). The higher seed producing varieties such as SRCP X 80 Ab 2767 and 79 CP 84 (Coker SR res) 80 SA 130; shorter varieties such as Kyto W 78394 Canada, 79 Ab 382 (TX) (80 SA 94) and SRCP X 80 Ab 2764 had relatively higher harvest index whereas the low seed producing varieties like CI-8251, PI-24480 and PI-5800 had lower harvest index than most other varieties. Generally, Oats varietal differences in terms of seed yield production performance, seed size, plant height and biomass yield contributed a considerable variation to their harvest index. Fekede (2004) generally concluded that high seed producing or shorter oats varieties had higher harvest index than low seed producing or taller varieties.

**Effect of locations/soil types on seed yield of oats varieties**

A variety trial was carried out at four locations to evaluate the seed yield of 13 selected oats varieties that were classified into early and late maturing types. Each set was planted in replicated trial at a seeding rate of 75 kg/ha at Holetta (red and black soils), Debre-zeit and Sheno (Table 2). Fertilizer at the rate of 100 kg/ha DAP was uniformly applied at the time of sowing. A higher mean seed yield was obtained by early (4.1 t/ha) than late (3.8 t/ha) maturing varieties. This could be due to the larger seed size (seed type) of the early maturing compared to the late maturing varieties. Variety 79 CP 84 (Coker SR res) 80 SA 130 from early maturing varieties and C7512/SRCP X 80 Ab 2252 from late maturing varieties gave the highest mean seed yield over locations. Generally, the highest mean seed yield was obtained from Holetta (red soil) and the lowest from Sheno on both maturity types.
Table 1. Grain filling period, grain maturity period, grain yield (t/ha), 1000-grain weight (g), and harvest index (HI %) of 20 oats varieties evaluated at Holetta.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Grain filling period (days)</th>
<th>Grain maturity period (days)</th>
<th>Grain yield (t/ha)</th>
<th>1000 seed weight (g)</th>
<th>HI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>79 Ab 382 (TX) (80 SA 94)</td>
<td>73cd</td>
<td>159.3i</td>
<td>7.20bode</td>
<td>25.7f</td>
<td>41.8ab</td>
</tr>
<tr>
<td>79 Ab 384 (TX) (80 SA 95)</td>
<td>73.0cd</td>
<td>160.3hi</td>
<td>7.33bode</td>
<td>30.5bcd</td>
<td>39.9ab</td>
</tr>
<tr>
<td>CI-8251</td>
<td>68.0ef</td>
<td>173.0k</td>
<td>3.83j</td>
<td>21.1gh</td>
<td>22.0f</td>
</tr>
<tr>
<td>Jasari</td>
<td>72.0de</td>
<td>163.3efg</td>
<td>6.57defg</td>
<td>29.5cd</td>
<td>33.9cd</td>
</tr>
<tr>
<td>SRCP X 80 Ab 2806</td>
<td>75.8abc</td>
<td>160.8ghi</td>
<td>8.60bc</td>
<td>31.5abc</td>
<td>39.7ab</td>
</tr>
<tr>
<td>Lampton</td>
<td>72.8cd</td>
<td>163.3efg</td>
<td>6.52defg</td>
<td>29.3d</td>
<td>33.7cd</td>
</tr>
<tr>
<td>C 7512/SRCP X 80 Ab 2252</td>
<td>79.8a</td>
<td>161.8ghi</td>
<td>7.71bcd</td>
<td>32.5ab</td>
<td>40.9ab</td>
</tr>
<tr>
<td>CI-8235</td>
<td>72.5cd</td>
<td>166.8cde</td>
<td>6.68def</td>
<td>29.4ef</td>
<td>34.9cd</td>
</tr>
<tr>
<td>CI-8237</td>
<td>72.8cd</td>
<td>161.8ghi</td>
<td>6.84def</td>
<td>29.4d</td>
<td>34.9cd</td>
</tr>
<tr>
<td>Grayalgiers</td>
<td>70.3def</td>
<td>186.8a</td>
<td>5.22ghi</td>
<td>25.0’</td>
<td>33.8cd</td>
</tr>
<tr>
<td>CP x/SRCP X 80 Ab 2291</td>
<td>75.8abc</td>
<td>160.8ghi</td>
<td>8.64b</td>
<td>30.3cd</td>
<td>37.9bc</td>
</tr>
<tr>
<td>79 CP 84 (Coker SR res) 80 SA 130</td>
<td>78.5ab</td>
<td>160.5ghi</td>
<td>10.56a</td>
<td>33.6a</td>
<td>42.9a</td>
</tr>
<tr>
<td>SRCP X 80 Ab 2764</td>
<td>74.3cd</td>
<td>162.3ghi</td>
<td>6.86code</td>
<td>28.8de</td>
<td>41.0ab</td>
</tr>
<tr>
<td>SRCP X 80 Ab 2767</td>
<td>75.8abc</td>
<td>162.3ghi</td>
<td>8.67b</td>
<td>28.6de</td>
<td>43.5a</td>
</tr>
<tr>
<td>Portage/Clintland 60 MN 16016</td>
<td>75.5bc</td>
<td>164.5defg</td>
<td>5.80efghi</td>
<td>22.7g</td>
<td>34.4cd</td>
</tr>
<tr>
<td>PI-338517</td>
<td>71.0def</td>
<td>185.8a</td>
<td>5.13ghi</td>
<td>25.5f</td>
<td>34.2cd</td>
</tr>
<tr>
<td>PI-244475</td>
<td>63.8g</td>
<td>166.0de</td>
<td>6.72def</td>
<td>25.2f</td>
<td>31.6de</td>
</tr>
<tr>
<td>PI-5800</td>
<td>67.3g</td>
<td>168.8f</td>
<td>4.87ghi</td>
<td>26.3f</td>
<td>27.8e</td>
</tr>
<tr>
<td>PI-244480</td>
<td>72.3cd</td>
<td>162.5ghi</td>
<td>4.28ghi</td>
<td>19.5h</td>
<td>23.0’</td>
</tr>
<tr>
<td>Kyto W 78394 Canada</td>
<td>79.0ab</td>
<td>166.3cd</td>
<td>7.22bode</td>
<td>26.7ef</td>
<td>41.9ab</td>
</tr>
<tr>
<td>Mean</td>
<td>73.1</td>
<td>165.8</td>
<td>6.76</td>
<td>27.4</td>
<td>35.5</td>
</tr>
<tr>
<td>CV (%)</td>
<td>3.97</td>
<td>1.18</td>
<td>18.21</td>
<td>5.48</td>
<td>8.96</td>
</tr>
</tbody>
</table>

Source: Fekede Feyissa, 2004
Table 2. Effect of locations/soil types on grain yield (t/ha) of early and late maturing oats varieties

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Holetta</th>
<th>Debre- zeit</th>
<th>Sheno</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Red soil</td>
<td>Black soil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early maturing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ky to W 78394 Canada</td>
<td>4.3</td>
<td>3.1</td>
<td>2.9</td>
<td>2.6</td>
</tr>
<tr>
<td>79 Ab 382 (TX) (80 SA 94)</td>
<td>6.9</td>
<td>3.3</td>
<td>4.6</td>
<td>2.8</td>
</tr>
<tr>
<td>79 Ab 384 (TX) (80 SA 95)</td>
<td>7.0</td>
<td>3.3</td>
<td>3.5</td>
<td>3.7</td>
</tr>
<tr>
<td>79 CP 84 (Coker SR res) 80 SA 130</td>
<td>7.9</td>
<td>3.1</td>
<td>4.4</td>
<td>2.3</td>
</tr>
<tr>
<td>C 7512/SRCP X 80 Ab 2267</td>
<td>7.3</td>
<td>3.2</td>
<td>4.3</td>
<td>2.4</td>
</tr>
<tr>
<td>SRCP X 80 Ab 2764</td>
<td>7.0</td>
<td>3.8</td>
<td>3.0</td>
<td>2.9</td>
</tr>
<tr>
<td>SRCP X 80 Ab 2806</td>
<td>6.8</td>
<td>3.3</td>
<td>3.7</td>
<td>2.1</td>
</tr>
<tr>
<td>Late maturing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portage/Clintland 60 MN 16016</td>
<td>5.2</td>
<td>3.4</td>
<td>4.1</td>
<td>2.1</td>
</tr>
<tr>
<td>C 7512/SRCP X 80 AB 2252</td>
<td>6.3</td>
<td>3.7</td>
<td>4.0</td>
<td>2.5</td>
</tr>
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<td>CI-8237</td>
<td>5.3</td>
<td>4.0</td>
<td>2.9</td>
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<td>CI-8235</td>
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<td>3.8</td>
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</tr>
<tr>
<td>Jasari</td>
<td>5.9</td>
<td>3.1</td>
<td>3.5</td>
<td>2.9</td>
</tr>
<tr>
<td>CP x/SRCP X 80 Ab 2291</td>
<td>6.0</td>
<td>3.5</td>
<td>4.2</td>
<td>2.5</td>
</tr>
</tbody>
</table>


Evaluation of vetch species

The experiment was conducted in 2009/10 to evaluate the seed yield performance of different vetch species at Holetta red soil and Ginchi black Vertisols (Table 3). The seeding rates- 25 kg/ha for *Vicia villosa*, *Vicia dasycarpa* and *Vicia atropurpurea*; 30 kg/ha for *Vicia sativa* and 75 kg/ha for *Vicia narbonensis* were used. At Ginchi site, sowing was done on cambered-beds to improve drainage and reduce water-logging problems of Vertisols. At sowing, 100 kg/ha DAP fertilizer was uniformly applied for all treatments at both locations. Days to seed harvest for tested vetch species varied across the sites (Table 3). Though, Ginchi site is relatively warmer than Holetta, early maturity for seed was recorded at Holetta than at Ginchi. This could be due to high and extended rainfall at Ginchi during cropping season and higher water holding capacity of Vertisols that encouraged vegetative growth and delayed seed harvesting stage. *Vicia narbonensis* showed significantly earlier (P<0.05) than the remaining species for seed harvest at both locations. On the other extreme, *Vicia villosa* was significantly late (P<0.05) for seed harvest at Holetta but not significantly late with *Vicia dasycarpa* and *Vicia atropurpurea* at Ginchi.
According to Getnet et al., (2003) *Vicia narbonensis* and *Vicia sativa* are early maturing; *Vicia dasycarpa* and *Vicia atropurpurea* are intermediate; and *Vicia villosa* is late maturing species recommended and utilized in the highlands of Ethiopia.

In some highland areas of Ethiopia, frost occurrence in the period from October to December is severe which substantially reduce forage yield of vetches in general and seed yield in particular. Hence, frost tolerance level was recorded from 1 to 5 (1= very low frost tolerance, while 5= very high frost tolerance) using visual observation during aforementioned frost period. Frost tolerance level for vetch species significantly (P<0.05) differed at Holetta but not at Ginchi (Table 3). The tolerance level was higher for *Vicia narbonensis* at both locations, whereas lower for *Vicia dasycarpa* and *Vicia sativa* with equal level of tolerance at Holetta and *Vicia villosa* at Ginchi. Frost is not a common problem at Ginchi due to relatively warmer climatic condition; however it is most often affects crop production at Holetta. Despite frost tolerance, days to maturity has a remarkable contribution in escaping frost damage. Normally, vetch species like *Vicia narbonensis* and *Vicia sativa* mature earlier for forage and seed filling stagess before the onset of frost, while species like *Vicia villosa* are late especially for seed and most often damaged by frost. Penology (earliness and lateness) of vetch species has a great effect on seed yield productivity especially in areas where frost problem is very high. The seed filling period (especially at the early stage) and frost occurring months coincided for most vetch species due to late sowing as a result of late onset of the rainfall that could be attributed to low seed yield during cropping season. For seed purpose, early maturing species should be grown at Holetta, whereas early and late maturing species at Ginchi, because seed yield reduction by frost is low due to relatively warm climatic condition. At Holetta, *Vicia narbonensis*, *Vicia sativa* and *Vicia dasycarpa* should be grown for seed production due to earliness to escape frost months, whereas late maturing species like *Vicia villosa* and *Vicia atropurpurea* should not be advisable to grow for seed purpose, but all vetch species should be grown for seed purpose at Ginchi.

After seed harvesting and cleaning, seed samples were taken and oven dried at 100°C for 48 hours to adjust moisture content at 10%, a recommended percentage level for legumes (Biru, 1979). Therefore, seed yield and thousand seed weight were then calculated at 10% moisture content. The seed yield of vetch species differed significantly (P<0.05) at Holetta, but not at Ginchi (Table 3). The highest seed yield was obtained from *Vicia sativa* (0.8 t ha⁻¹) at Holetta and *Vicia narbonensis* (2.9 t ha⁻¹) at Ginchi, whereas the lowest yield was obtained from *Vicia narbonensis* (0.4 t ha⁻¹) at Holetta and *Vicia atropurpurea* (2.0 t ha⁻¹) at Ginchi. Narbon vetch was affected by root rot disease caused by *Fusarium solani* at both locations; however the damage was higher at Holetta than Ginchi. Consequently, a considerable number of seedlings were affected by...
this disease so that the seed yield of narbon vetch was lower during cropping season especially at Holetta.

Thousand seed weight of vetch species showed a significant (P<0.05) difference at both locations, which ranged from 44.1 to 222.8 g with a mean of 81.7 g at Holetta and from 42.5 to 242.2 g with a mean of 86.3 g at Ginchi (Table 3). The highest thousand seed weight was for *Vicia narbonensis* at both locations, whereas the lowest for *Vicia dasycarpa* and *Vicia villosa* at Holetta and Ginchi respectively. Though, *Vicia narbonensis* had the highest thousand seed weight, its seed yield was comparatively lower due to lower establishment performance (as a result of disease problems) at Holetta. Generally, vetch species with higher thousand seed weight gave relatively higher seed yield. Getnet et al., (2003) and Fekede (2004) also reported that most of the oats varieties with high seed yield showed higher 1000 kernel weight. In general, Vetch species (*V. narbonensis* and *V. sativa*) which have an erect growth habit and early maturing had comparatively higher thousand seed weight than creeping growth habit and intermediate to late maturing vetch species. The difference could be due to inherent variation in seed size complemented with the environmental and soil conditions. This agronomic trait is important for seed rate determination of vetch species. Fekede (2004) also reported that thousand seed weight has got practical significance in estimating seeding rate for each oat variety in order to ensure that equal number of seeds could be sown per unit area.

Table 3. **Average days to seed harvest, seed yield (t ha⁻¹), thousand seed weight (g) and frost tolerance level of Vicia species at Holetta and Ginchi.**

<table>
<thead>
<tr>
<th>Species</th>
<th>Days to seed harvest</th>
<th>Seed yield (t ha⁻¹)</th>
<th>Thousand seed weight (g)</th>
<th>Frost tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Holetta</td>
<td>Ginchi</td>
<td>Holetta</td>
<td>Ginchi</td>
</tr>
<tr>
<td><em>Vicia sativa</em></td>
<td>119.7c</td>
<td>151.3b</td>
<td>0.8a</td>
<td>2.7</td>
</tr>
<tr>
<td><em>Vicia villosa</em></td>
<td>149.9a</td>
<td>157.9a</td>
<td>0.7a</td>
<td>2.3</td>
</tr>
<tr>
<td><em>V. narbonensis</em></td>
<td>113.5d</td>
<td>134.6c</td>
<td>0.4b</td>
<td>2.9</td>
</tr>
<tr>
<td><em>V. dasycarpa</em></td>
<td>129.7b</td>
<td>156.8b</td>
<td>0.7a</td>
<td>2.1</td>
</tr>
<tr>
<td><em>V. atropurpurea</em></td>
<td>135.3b</td>
<td>159.3a</td>
<td>0.5ab</td>
<td>2.0</td>
</tr>
<tr>
<td>Mean</td>
<td>129.6</td>
<td>152.0</td>
<td>0.6</td>
<td>2.4</td>
</tr>
<tr>
<td>CV (%)</td>
<td>4.08</td>
<td>4.05</td>
<td>12.42</td>
<td>5.86</td>
</tr>
</tbody>
</table>

*Source: Gezahagn Kebede, 2011*
Effect of Agronomic Practices on Seed Production of Annual Forage Crops

Effect of seeding rate on seed yield of oats varieties

Eight oats varieties varying in 1000-seed weight between 21-36 g were evaluated for two seasons to establish appropriate seeding rate and to determine the effect of fertilizer application on seed yield of oats varieties (Table 4) at Holetta, Ginchi and Kulumsa. The average seed yield of the tested oats varieties for different seeding rate ranged from 2.7 to 4.9 t/ha with a mean of 4.0 t/ha with fertilizer application and 2.4 to 4.6 t/ha with a mean of 3.6 t/ha without fertilizer application over locations and over years. Variety 79 CP 84 (Coker SR res) 80 SA 130 gave the highest seed yield with and without fertilizer application; over locations and seasons; and for different seeding rates. Oats varieties can successfully grow on less fertile soils without fertilizer application. Generally, the data collected for two consecutive years and over locations indicated that seeding rate from 80-100 kg/ha of oats varieties depending on viability of seeds can produce reasonable seed yield at Holetta, Ginchi and Kulumsa without fertilizer application, however, fertilizer application showed some improvement on production of seed yield.

Effect of single and re-growth harvests on seed yield of oats varieties

Oats varieties were sown at a seeding rate of 75 kg/ha to evaluate the effect of single and re-growth harvests on seed yield at Holetta and Debre-zzeit (Table 5). At planting 100 kg/ha DAP was uniformly applied for all experimental units. Each experimental plot was divided into two parts. The first half plot was harvested at knee height and left for re-growth for seed harvest and the other half was left un-harvested until seed maturity. At both locations there was difference in seed yield among the varieties for both single and re-growth harvests. Generally, mean seed yield was reduced by about 49% when the varieties were harvested at Knee height and left for re-growth for seed compared to single harvest.
Table 4. Mean grain yield (t/ha) of different oats varieties as affected by seeding rate and fertilizer application at Holetta, Ginchi and Kulumsa in 2004 and 2005.

<table>
<thead>
<tr>
<th>Oats variety</th>
<th>With fertilizer</th>
<th>Mean</th>
<th>Without fertilizer</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seeding rate kg/ha</td>
<td></td>
<td>Seedling rate kg/ha</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>120</td>
</tr>
<tr>
<td>79 CP 84 (Coker SR res) 80 SA 130</td>
<td>5.3</td>
<td>5.1</td>
<td>4.2</td>
<td>4.9</td>
</tr>
<tr>
<td>C7512/SRCP X 80 Ab 2291</td>
<td>4.4</td>
<td>4.7</td>
<td>4.4</td>
<td>4.7</td>
</tr>
<tr>
<td>Kyto W 78394 Canada</td>
<td>4.6</td>
<td>4.5</td>
<td>4.4</td>
<td>4.6</td>
</tr>
<tr>
<td>CI-8237</td>
<td>3.8</td>
<td>3.9</td>
<td>3.4</td>
<td>3.8</td>
</tr>
<tr>
<td>Portage/Clintland 60 MN 16016</td>
<td>4.4</td>
<td>4.6</td>
<td>4.2</td>
<td>4.2</td>
</tr>
<tr>
<td>CI-8251</td>
<td>3.1</td>
<td>3.2</td>
<td>3.1</td>
<td>3.4</td>
</tr>
<tr>
<td>CI-8235</td>
<td>3.1</td>
<td>3.4</td>
<td>3.5</td>
<td>3.7</td>
</tr>
<tr>
<td>PI- 244480</td>
<td>2.7</td>
<td>2.8</td>
<td>2.5</td>
<td>2.9</td>
</tr>
<tr>
<td>Mean</td>
<td>3.9</td>
<td>4.0</td>
<td>3.7</td>
<td>4.0</td>
</tr>
</tbody>
</table>


*1 = 60, 2 = 80, 3 = 100, 4 = 120, 5 = 140 kg/ha seeding rate
Table 5. Effect of single harvest and re-growth on grain yield (t/ha) of different oats varieties evaluated over locations

<table>
<thead>
<tr>
<th>Oats variety</th>
<th>Holetta</th>
<th>Debre-zeit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single harvest</td>
<td>Re-growth</td>
</tr>
<tr>
<td>Mn 799883-85 Minnesta</td>
<td>4.2</td>
<td>2.6</td>
</tr>
<tr>
<td>Portage/Clintland 60 MN 16016</td>
<td>3.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Kyoto W 78394 Canada</td>
<td>4.3</td>
<td>3.5</td>
</tr>
<tr>
<td>79 Ab 382 (TX) (80 SA 94)</td>
<td>4.0</td>
<td>3.2</td>
</tr>
<tr>
<td>79 Ab 384 (TX) (80 SA 95)</td>
<td>4.2</td>
<td>3.0</td>
</tr>
<tr>
<td>79 CP 84 (Coker SR res) 80 SA 130</td>
<td>4.4</td>
<td>2.8</td>
</tr>
<tr>
<td>C 7512/SRCP X 80 AB 2252</td>
<td>4.2</td>
<td>3.2</td>
</tr>
<tr>
<td>C 7512/SRCP X 80 Ab 2267</td>
<td>4.4</td>
<td>3.4</td>
</tr>
<tr>
<td>CP x/SRCP X 80 Ab 2291</td>
<td>3.8</td>
<td>3.0</td>
</tr>
<tr>
<td>CI-8237</td>
<td>3.4</td>
<td>1.3</td>
</tr>
<tr>
<td>CI-8235</td>
<td>3.5</td>
<td>1.3</td>
</tr>
<tr>
<td>SR-CpX80 Ab 2726</td>
<td>3.9</td>
<td>2.5</td>
</tr>
<tr>
<td>SRCP x 80 Ab 2764</td>
<td>4.9</td>
<td>3.2</td>
</tr>
<tr>
<td>SRCP x 80 Ab 2806</td>
<td>4.6</td>
<td>3.0</td>
</tr>
<tr>
<td>QCL x QC2</td>
<td>4.4</td>
<td>2.9</td>
</tr>
<tr>
<td>Jasari</td>
<td>4.3</td>
<td>1.5</td>
</tr>
<tr>
<td>Mean</td>
<td>4.1</td>
<td>2.6</td>
</tr>
</tbody>
</table>

*Source: HRC progress report, 1981-2006*

**Effect of planting methods on seed yield of vetch species**

Seed yields of climbing vetches from bulk fields are very low, however; these yields could be substantially increased by using suitable agronomic and cultural practices. One possible way of attaining this is by encouraging the natural climbing habit of vetches so as to allow multiple seed collection without damaging the remaining crops. Therefore, *Vicia dasycarpa* (Lana) was planted at a seeding rate of 25 kg/ha at Holetta, Debre-zeit and Hawassa using four planting methods (Table 6). The methods were row planting on flat land at 30 cm inter row distance, A-frame shape at 1.5 m between centers, fences at 1 m apart and broadcasting. At sowing, fertilizer at a rate of 100 kg/ha DAP was applied for all methods. The mean seed yield for all planting methods was higher at Holetta (2.4 t/ha) followed by Debre-zeit (0.9 t/ha) and Hawassa (0.6 t/ha). The seed yield could be improved by 31-38% using simple sticks (fence) to support the plant. Supporting structure allowed better aeration and more light.
penetration resulting in better growth and multiple harvesting was more possible than either broadcast or row planting. Smallholder farmers can get a reasonable amount of seed if they plant vetch around their fences. Generally, vetch is weak stemmed and requires a supporting structure which holds them erect making vigorous growth to attain maximum seed production. So, farmers can use either of the two systems than flat planting to get better yields of vetch seeds. But, these results should be supported by an economic study to determine the cost of materials and labor requirement for the use of these systems in order to give a concrete recommendation.

Table 6. Mean seed yield (t/ha) of vetch with and without support at three locations

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Holetta</th>
<th>Debre-zeit</th>
<th>Hawassa</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row planting</td>
<td>1.8</td>
<td>0.8</td>
<td>0.4</td>
<td>1.0</td>
</tr>
<tr>
<td>A-frame shape</td>
<td>2.8</td>
<td>1.1</td>
<td>0.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Fence</td>
<td>3.2</td>
<td>1.0</td>
<td>0.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Broadcast</td>
<td>1.7</td>
<td>0.8</td>
<td>0.6</td>
<td>1.1</td>
</tr>
<tr>
<td>Mean</td>
<td>2.4</td>
<td>0.9</td>
<td>0.6</td>
<td>1.3</td>
</tr>
</tbody>
</table>

(Source: HARC progress report, 1981-2006)

Effect of seed rate and row spacing on seed yield of vetch species

Five seeding rates and four row spacing treatments were used to evaluate their effect on *Vicia dasycarpa* (Lana) seed production at Holetta (Table 7). Mean seed yield was the lowest for 10 kg/ha seeding rate and the highest for 30 kg/ha seeding rate. However, the difference in seed yield among the other seeding rates was very slight. On the other hand, row spacing influenced seed yield and the highest yield (1.2 t/ha) was obtained from a row spacing of 80 cm. Moreover, the effects of row spacing and broadcasting were further evaluated at Holetta, Debre-zeit and Hawassa (Table 8). The result indicated that mean seed yield difference between different row spacing over locations was very low but, the difference was comparatively higher when compared to broadcasting. Moreover, row planted vetch was easier to weed and harvest the seeds. Generally, a seeding rate of 25 kg/ha and 30 cm row spacing have been used for planting of *Vicia dasycarpa* (Lana) for forage and seed purposes in the central highlands of Ethiopia.
Table 7. Effect of seed rate and row spacing on vetch seed production (t/ha) evaluated at Holetta

<table>
<thead>
<tr>
<th>Seed rate (kg/ha)</th>
<th>Spacing (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>1.1</td>
</tr>
<tr>
<td>20</td>
<td>1.0</td>
</tr>
<tr>
<td>30</td>
<td>1.2</td>
</tr>
<tr>
<td>40</td>
<td>0.7</td>
</tr>
<tr>
<td>50</td>
<td>0.6</td>
</tr>
<tr>
<td>Mean</td>
<td>0.9</td>
</tr>
</tbody>
</table>


Table 8. Effect of row spacing on seed production (t/ha) of vetch over locations

<table>
<thead>
<tr>
<th>Row spacing (cm)</th>
<th>Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Holetta</td>
</tr>
<tr>
<td>20</td>
<td>2.0</td>
</tr>
<tr>
<td>40</td>
<td>2.3</td>
</tr>
<tr>
<td>60</td>
<td>2.2</td>
</tr>
<tr>
<td>80</td>
<td>2.2</td>
</tr>
<tr>
<td>Broadcast</td>
<td>-</td>
</tr>
<tr>
<td>Mean</td>
<td>2.2</td>
</tr>
</tbody>
</table>


Effect of harvesting stage on seed yield of clovers

Five selected annual clovers were planted on red and black soils at Holetta to evaluate their seed production potential and effect of harvesting dates (weeks after flowering) on seed yield (Table 9). Mean seed yield was comparatively better on black soil (225 kg/ha) than red soil (144 kg/ha) for different harvesting weeks after flowering. The mean seed yields for clovers on red soil showed that a decreasing trend with delayed harvesting after flowering whereas an increasing trend was observed until third harvesting weeks after flowering on black soils. High and fast seed shattering problem was observed on red soil due to early drying out of the soil compared to black soil so that early harvesting was very important to produce higher seed yield from red soil. *Trifolium steudneri* gave the highest seed yield and less affected with different harvesting dates on both black and red soils. *Trifolium quartinianum* and *Trifolium decorum* were very sensitive to late harvesting dates on red soil so that harvesting date should be early to minimize the loss due to shattering problem.
Generally, the mean seed yield for clovers were higher when harvested at first and third weeks after flowering on red and black soils respectively.

Table 9. Effect of harvesting stage on seed yield (t/ha) of clovers on red and black soils at Holetta

<table>
<thead>
<tr>
<th>Soil types</th>
<th>Species</th>
<th>Harvesting weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Red soil</td>
<td>Trifolium quartinianum</td>
<td>117</td>
</tr>
<tr>
<td></td>
<td>Trifolium rueppelianum</td>
<td>210</td>
</tr>
<tr>
<td></td>
<td>Trifolium steudneri</td>
<td>219</td>
</tr>
<tr>
<td></td>
<td>Trifolium decorum</td>
<td>171</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>179</td>
</tr>
<tr>
<td>Black soil</td>
<td>Trifolium quartinianum</td>
<td>210</td>
</tr>
<tr>
<td></td>
<td>Trifolium tembense</td>
<td>151</td>
</tr>
<tr>
<td></td>
<td>Trifolium steudneri</td>
<td>260</td>
</tr>
<tr>
<td></td>
<td>Trifolium decorum</td>
<td>195</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>204</td>
</tr>
</tbody>
</table>

**Conclusion**

The tested 20 oats varieties varied significantly in seed filling and maturity periods, seed yield, thousand seed weight and harvest index. Oats varieties respond differently in terms of seed production performance over locations and soil types. Generally, early maturing oats varieties are seed type and comparatively gave better seed yield than late maturing forage type varieties. The seed yield and its related performance of vetch species were highly influenced by environmental and soil conditions. Oats varieties with seeding rate of 80-100 kg/ha can produce reasonable seed yield over locations without fertilizer application. Though some improvement was observed with fertilizer application, the difference is quite low because oats can grow successfully on less fertile soils. Though oats is annual forage grass, double harvesting (at knee height for forage and the re-growth left for seed harvest) is possible due to rejuvenating nature of the plant, however, the seed yield of the re-growth harvest reduced by half when compared to single harvest. The growth habits of vetch species are erect, semi-erect and climbing which have tremendous effect on seed production. Accordingly, weak stemmed (climbing) vetches need a supporting structure when compared to other type of growth habit to get maximum seed yield. Seeding rate and row spacing also have an effect on seed production of vetch species. Therefore, seeding rate of 25 kg/ha and row spacing of 30 cm have been used for sowing of *Vicia dasycarpa* for better seed production purpose. Seed yield of clovers are highly affected by delayed
harvesting due to fast and high shattering problem. The effect of harvesting stage on seed yield of clovers is more manifested on red soil than black soil because of lower water holding capacity of the former soil which makes early maturity and fast shattering of the seeds than the later soil type.

References


The Status of Forage Research in the Dryland Areas of Tigray

Mehari Kebede
Tigray Agricultural Research Institute, Mekelle

Introduction

In Tigray, the major livestock feed sources are cereal crop-residues (wheat, barley, tef, maize, sorghum), green grass and hay from grazing lands and area closures, improved forages from gullies and irrigated lands, and industrial by-products. Due to the large livestock population, the available feed is not sufficient to boost livestock production and productivity and meet the high demand for livestock products by the increasing population of the region. The regional government has been designing and implementing appropriate livestock improvement interventions suited to the different agro-ecologies, farming systems and socio-economic conditions to address these constraints. This paper describes the status of forage research activities and identifies adapted forage species for the different agro-ecologies of the region and makes proposals for future forage research-extension activities.

Forage Research Achievements

Grass species

Screening and establishment of oats (Avena sativa) accessions
Six oats varieties at Illala (Mekelle) and five oats varieties at Korem was tested in 2007. Among the six oats varieties tested at Illala, CI-8237, 80Ab27643 and Lampton gave the highest average herbage dry matter yields of 10.48, 9.04 and 8.18t/ha, respectively. Similarly, Jasari, 2806 and 79Ab3582 gave average forage DM yields of 7.34, 6.76 and 6.38t/ha, respectively. The herbage yield of the accessions/varieties was better at Korem than at Adet and Mekelle Agricultural Research Centers (5.83-10.69 and 6.76-10.49 t/ha) and agrees with the report of Fekede et al., 2008 (9.86-14.58 t/ha). The oats accession/varieties CI-8237 gave a higher herbage yield than other accessions at both Illala and Korem.
**Screening of napier grass (Pennisetum purpureum) genotypes**

Out of the four napier accessions evaluated at Illala, accession 16803 gave the highest herbage DM yield of 41.6 t/ha and followed by accession 14984 (41.34 t/ha). The accession obtained from GTZ gave the lowest DM yield of 30.25 t/ha. Plant height was observed to be 220 cm and 216 cm for 16822 and GTZ, respectively where as 14984 and 16803 were shorter than other accessions. Generally, no disease or pests were observed in all the accessions. The accessions 14984 and 16803 produced 66 and 62 tillers, respectively while the other two accessions produced 46 tillers at harvest.

**Forage legumes**

**Evaluation of alfalfa under irrigation**

Among the four alfalfa accessions evaluated, accession no. 6984 outperformed the other accessions with a mean DM yield of 2.79 t/ha. The lowest herbage DM yield (1.49 t/ha) was obtained from the accession obtained from relief society of Tigray (REST) which. Days to 50% flowering also ranged from 80–81 days and plant height at harvest ranged from 46-61 cm. The accession obtained from REST was shorter than Hunter River. No disease or pest problems were observed on any of the accessions during the trial.

**Evaluation of cajanus, lablab, and cow pea**

Six accessions of *Cajanus cajan* (Accessions 11555, 11560, 11563, 11566, 11575, GTZ) were tested at Humera, Illala and Abergelle. Accession numbers 11563 (7.72 t/ha DM), 11566 (1.28 t/ha DM) and 11555 (2.64 t/ha DM) were the best performing once in terms of biomass yield at Illala , Humera and Abergelle, respectively. The yield of almost all accessions of *Cajanus cajan* was better at Illala than at Abergelle and Humera. Generally, no disease or pest problems were observed on the accessions at all the research sites.

Similarly lablab accessions 147, 507, 6529, 912, 1034, 10979, 11609, 11640 were tested at Humera, Sheraro, Illala and Abergelle, but not all accessions tested in all the sites. The yield of the tested accessions was better at Abergelle and Illala than the other two centers. Accession no. 912 gave the highest herbage yield followed by accession no. 1034 at Abergelle. It was observed that the tested lablab accessions were affected by moisture stress at Humera and Sheraro and their growth was impaired before they reached the recommended stage for feed of 50% flowering. This factor was responsible for the low herbage yield of the accessions in the two centers. No disease and pest problems were observed at all the centers.

Cowpea accessions including black eye bean, white wonder, TVU1977D1, 12668, 933 and checks were evaluated at Humera, Sheraro and Abergelle. They produced herbage yields ranging from 4.17–7.54 t/ha at Abergelle compared to
Humera and Sheraro. Most of the introduced accessions gave higher herbage yields than the local checks, suggesting the possibility to improve feed supply through the promotion of high yielding accessions around Abergelle area. At Abergelle high production of herbage produced by the varieties black eye bean (7.54 t/ha DM), white wonder (6.10 t/ha DM) and TVU1977D1(4.46 t/ha DM). While among the tested varieties the white wonder was the highest producer at Sheraro (5.97 t/ha DM) and Humera (2.07 t/ha DM)

Vetch species including Vicia dasycarpa, V, villosa and V. sativa were tested at Abergelle and Korem. The herbage yield of the tested Vicia species and accessions was by far better at Korem than at Abergelle. The highest herbage yield was obtained from Vicia sativa followed by Vicia dasycarpa. This shows that it will be very promising to promote these species to improve both feed supply and quality around Korem area.

**Conclusions and Recommendations**

In the Tigray region, various exotic forage legumes and grasses have been introduced and evaluated at different centers representing different agro-ecologies. Many promising accessions were identified for adaptability and herbage yield in the testing centers. These accessions could be candidates for additional forage research and development in suitable agro-ecologies of the region. However, they are not promoted and utilized by farmers. In this regard, the need for forage seed for promotion of the varieties is critically very relevant. Therefore, development forage production technologies and production of forage seeds at large scale is a priority areas. In addition to this forage development strategies in integration with food crops and natural conservation works should be strengthened and necessary technologies should be developed.

**References**


TARI (Tigray Agricultural Research Institute), Alamata Agricultural Research Center, animal science research division, 2010. Progress report.
TARI (Tigray Agricultural Research Institute), Humera Agricultural Research Center, animal science research division, 2010. Progress report.
TARI (Tigray Agricultural Research Institute), Mekelle Agricultural Research Center, animal science research division, 2007. Progress report.
Introduction

The major constraint for increasing livestock production in the Amhara Region is shortage of animal feed in terms of both quantity and quality. The available feed does not meet more than 40% to 60% of the amount required for regions where crop farming dominates (Seyoum, 2007). Natural pastures provided more than 90% of the animal feed in the past decades (Judi et al., 1987, as cited by Alemu, 1998). But nowadays, natural pasturelands are confined to degraded shallow upland soils, fallow crop lands, and lands that cannot be cropped due to physical constraints such as flooding and water-logging. Natural pastures are low yielding and their production is insufficient. The dry matter yield of heavily grazed grasslands does not exceed 1.5 t/ha in the highlands above 2,600 m or 2.5 t/ha below this altitude (Alemu, 1998). In most parts of the country, grazing conditions are favorable for only four or five months per year. In recent years, grazing areas have been shrinking because of rapid expansion of arable lands to provide food for the ever-increasing human population. Selection of high-yielding and better-quality forage varieties and development of improved feeding packages are important to overcome the existing feed shortage problem.

The introduction of improved forages into the farming systems is expected to solve the severe feed shortages that the region is presently facing. However, most of the recommended pasture and forage crops have not yet been introduced and adapted by the farming community. Unavailability of seed is among the major constraints limiting the promotion and utilization of improved forage crops.

The objectives of this paper were to review and document the research findings with respect to pasture and forage seed production in the region, identify constraints and suggest future directions for pasture and forage seed research.

Research on Forage Seed Production

Past research works on pasture and forage crops in the country were mainly focused on adaptability, dry matter production, and to some extent quality evaluation. Based on these criteria, a number of grasses, herbaceous legumes,
and browse species were selected and recommended for different environments (Table 1). Even though most of these adaptable species are capable of flowering and producing healthy and viable seeds, very little work has been done on their seed production potential in Ethiopia.

Table 1. Major forage species recommended for different agro-ecologies.

<table>
<thead>
<tr>
<th>Species/varieties</th>
<th>Common name</th>
<th>Recommended Agro-ecology*</th>
<th>Propagation method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Pennisetum purpureum</em></td>
<td>Elephant grass</td>
<td>HA, MA, LA</td>
<td>Stem cut/root splits/shoots</td>
</tr>
<tr>
<td><em>Chloris gayana</em></td>
<td>Rhodes</td>
<td>MA</td>
<td>Seed/root splits</td>
</tr>
<tr>
<td><em>Panicum coloratum</em></td>
<td>Guinea grass</td>
<td>MA</td>
<td>Seed/root splits</td>
</tr>
<tr>
<td><em>Phalaris aquatica</em></td>
<td>Phalaris grass</td>
<td>HA</td>
<td>Seed/root splits</td>
</tr>
<tr>
<td><em>Avena sativa</em></td>
<td>Oats</td>
<td>HA, MA</td>
<td>Seed</td>
</tr>
<tr>
<td>Legumes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Medicago sativa</em></td>
<td>Alfalfa</td>
<td>HA, MA, LA</td>
<td>Seed</td>
</tr>
<tr>
<td><em>Lotus corniculatus</em></td>
<td>Birds foot trefoil</td>
<td>HA</td>
<td>Seed/root split</td>
</tr>
<tr>
<td><em>Desmodium uncinatum</em></td>
<td>Silver leaf</td>
<td>MA</td>
<td>Seed/root splits</td>
</tr>
<tr>
<td><em>Desmodium intortum</em></td>
<td>Green leaf</td>
<td>MA</td>
<td>Seed/root splits</td>
</tr>
<tr>
<td><em>Trifolium quartinianum</em></td>
<td>Clover</td>
<td>HA</td>
<td>Seed</td>
</tr>
<tr>
<td><em>Vicia villosa</em></td>
<td>Vetch</td>
<td>HA, MA</td>
<td>Seed</td>
</tr>
<tr>
<td><em>Vigna unguiculata</em></td>
<td>Cowpea</td>
<td>MA, LA</td>
<td>Seed</td>
</tr>
<tr>
<td>Browse trees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Sesbania sesban</em></td>
<td>Sesbania</td>
<td>MA, LA</td>
<td>Seed/seedlings</td>
</tr>
<tr>
<td><em>Leucaena spp.</em></td>
<td>Leucaena</td>
<td>MA, LA</td>
<td>Seed/seedlings</td>
</tr>
<tr>
<td><em>Chamaecytisus palensis</em></td>
<td>Tagasaste/ Tree Lucerne</td>
<td>HA</td>
<td>Seed/seedlings/ stem cuts</td>
</tr>
</tbody>
</table>

*HA = High Altitude, MA = Mid Altitude, LA = Low Altitude

The production of seed of perennial grasses is difficult in the tropics. Flower spikes appear gradually, and when some shoots have ripe seeds, others have only begun to flower (Bogdan, 1977) causing uneven ripening and low seed viability. Seeds may easily be shed during ripening. All these factors can reduce the potential seed yield of grasses. Grasses such as *Phalaris aquatica* and *Panicum coloratum* retain the seed shattering characteristics of their wild ancestors. As a result, there are often serious harvesting problems resulting in low yield and inferior seed quality (McWilliam and Gibbon, 1981).

Seed production methods of forage crops are quite different from cereal crops (Alemu, 1998). Each herbage plant has its own peculiarities. It is important to
know the proper rate, time, and method of seeding, as well as the best stage of plant development at which the seed is sufficiently mature to harvest.

### Annual Species

#### Oats

A trial was conducted at Andassa Agricultural research Center (AARC) and Sirinka Agricultural Research Center (SARC) to determine the seed yield potential of different oats varieties (*Avena sativa*). The results showed that some varieties gave higher and others lower seed yield across locations (Table 2).

**Table 2. Seed yield (q/ha) of oats in different agro-ecologies.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adet</td>
<td>Jamma</td>
</tr>
<tr>
<td>CI-8237</td>
<td>11.1</td>
<td>19.6</td>
</tr>
<tr>
<td>CI-8235</td>
<td>11.0</td>
<td>18.3</td>
</tr>
<tr>
<td>CI-8251</td>
<td>12.0</td>
<td>13.0</td>
</tr>
<tr>
<td>Lampton</td>
<td>11.7</td>
<td>21.7</td>
</tr>
<tr>
<td>Jasari</td>
<td>12.7</td>
<td>21.4</td>
</tr>
<tr>
<td>6710</td>
<td>10.1</td>
<td>17.2</td>
</tr>
<tr>
<td>Grayalgiers</td>
<td>10.1</td>
<td>-</td>
</tr>
<tr>
<td>7512/SRCPX80AB225</td>
<td>12.9</td>
<td>20.4</td>
</tr>
<tr>
<td>7122/SRCPX 80 AB 2267</td>
<td>32.7</td>
<td>11.2</td>
</tr>
<tr>
<td>CPX/SRCPX 80 AB 2291</td>
<td>30.4</td>
<td>12.9</td>
</tr>
<tr>
<td>7512/SRCPX80AB</td>
<td>-</td>
<td>14.5</td>
</tr>
<tr>
<td>79AB382/TX80</td>
<td>15.1</td>
<td>21.1</td>
</tr>
<tr>
<td>SRCPX 80 AB 2252</td>
<td>32.1</td>
<td>12.7</td>
</tr>
</tbody>
</table>

*Source: AARC Progress Report (2002); SARC Progress Report (2007)*

#### Vetches

A trial was also conducted at Adet Research Center to determine seed yield of vetch species. Among the four vetch species tested, *Vicia dasycarpa* 6213 gave higher seed yield than other varieties. Another experiment was done to evaluate seed production performance in the highlands of the Eastern Amhara region at Sirinka Agricultural Research Center on six selected vetch species and accessions. They produced substantial seed yields (Table 3).
Table 3. Seed yield (q/ha) of forage vetches tested at different locations.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adet</td>
<td>Jamma</td>
</tr>
<tr>
<td>Vicia atropurpurea 1481</td>
<td>-</td>
<td>6.9</td>
</tr>
<tr>
<td>Vicia atropurpurea 156</td>
<td>-</td>
<td>9.7</td>
</tr>
<tr>
<td>Vicia benghalensis 6798</td>
<td>-</td>
<td>9.8</td>
</tr>
<tr>
<td>Vicia dasycarpa 6213</td>
<td>14.2</td>
<td>10.7</td>
</tr>
<tr>
<td>Vicia sativa 1486</td>
<td>-</td>
<td>6.6</td>
</tr>
<tr>
<td>Vicia villosa 6792</td>
<td>9.3</td>
<td>9.5</td>
</tr>
<tr>
<td>Vicia atropurpurea 1487</td>
<td>8.1</td>
<td>-</td>
</tr>
<tr>
<td>Vicia sativa 5235</td>
<td>11.9</td>
<td>-</td>
</tr>
</tbody>
</table>


Cowpea

On station adaptation trials were conducted at Sekota Agriculture Research Center for three years to study the production performance of cowpea (Vigna unguiculata). All introduced varieties were well adapted to the moisture stressed area and gave higher seed yield than the local variety (Table 4).

Table 4. Seed yield (q/ha) of cowpea varieties tested in moisture stressed areas of Waghimra.

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Seed yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>22.7</td>
</tr>
<tr>
<td>TVX11424</td>
<td>29.5</td>
</tr>
<tr>
<td>IT86D378</td>
<td>32.9</td>
</tr>
<tr>
<td>IT92KD258-9</td>
<td>36.8</td>
</tr>
<tr>
<td>IT93K2946-1</td>
<td>26.4</td>
</tr>
<tr>
<td>IT90K284-9</td>
<td>32.0</td>
</tr>
<tr>
<td>IT89KD-395</td>
<td>33.6</td>
</tr>
<tr>
<td>WWT</td>
<td>33.5</td>
</tr>
<tr>
<td>MELNI-963</td>
<td>29.8</td>
</tr>
<tr>
<td>IT84D329</td>
<td>30.1</td>
</tr>
</tbody>
</table>

Lablab
Among the five lines of Lablab (*Lablab purpureus*) tested for seed production at Shoa Robit for two consecutive years, CV. 11640 was found to be the highest yielder with 12.82 q/ha, followed by High worth with 11.40 q/ha (unpublished data, Debre Berhan Research Center).

Perennial Species

Rhodes and Panicum grasses
Experiments were carried out at Adet Agricultural Research Center to determine the seed yields of *Chloris gayana* and *Panicum coloratum*. The two species gave seed yields of about 5 and 4 q/ha, respectively (AARC, 2002). Similarly, Alemu (1998) reported that research observations made on the seed production potential of some forage crops in the sub-humid and mid-altitude environment of Ethiopia indicated that *Chloris gayana* and *Panicum coloratum* could produce up to 7 and 5 q/ha seed, respectively.

Seed Quality
Seed quality refers to purity, germination capacity, and moisture content of the seed. Seed quality deteriorates if seeds are kept for long periods under uncontrolled environmental conditions. A study conducted at Debre Berhan revealed that for *Festuca arundinacea* and *Phalaris aquatica* seed viability declined after two and three years of storage time respectively, while *Trifolium tembense* and *Vicia dasycarpa* could be kept safely for four and five years, respectively (Aschalew et al., 2009).

To maintain maximum viability, most seed must be stored at a fixed moisture content (7-8%) and temperature, usually 0-4°C (Dorrell, 1984), but this may not always be possible because of lack of facilities. A trial was conducted in the highlands (2,400 m) to determine the shelf life of locally collected herbage seed stored at ordinary temperature and humidity. The results indicated that the viability of grass seeds was reduced by about 50% and that of Alfalfa seed by 25%, while no reduction was observed in the viability of vetch seed after five years of storage (Alemu, 1998).
Constraints to Forage Seed Production

Research challenges
There is lack of research focus in the area of forage and pasture seed production. Suitable sites have not been identified for forage seed production and agronomic practices, which improve seed production, are not adequately established. There is also a serious lack of trained workforce in the area of forage seed research and production.

Lack of farmer interest and private sector involvement
Systems based forage and pasture seed production by farmers and private companies is limited. There is lack of farmer interest, for seed production of forage species for which there is demand. This can be explained by the fact that prices paid to seed producers are not competitive when compared to some other remunerative crops. Lack of specific equipment for seed production and lack of technical support to farmers translate directly to low yield.

Extension and promotion
The current extension efforts for the promotion of pasture and forage crops are insufficient and limited to few market oriented livestock producers, conservation of natural resources, and rehabilitation of degraded pasturelands. These efforts have to be sustained by encouraging private investment in pasture management and selection of equipment and community involvement in pasture improvement. Extension efforts in seed production have to be reinforced to allow farmers to master forage seed production techniques.

Conclusion and Recommendations
Pasture and forage research in the regional program of the ARARI has gained momentum in the past 11 years, but research on forage seed production is at its infant stage. Seed production methods for forage crops are quite different from those applied in cereal crops. Each herbage species has its peculiarities of seeding rate, time of sowing and method of planting and harvesting. Owing to the low demand for improved forage seeds, there has been very negligible private sector involvement in forage seed production. However, because of the severe feed shortage problem and the recognition by farmers, demand for improved forage seed is increasing. Therefore, forage seed production should be strengthened in both the public and private sectors. This would require the following actions:
• Identify suitable environments for forage seed production;
• Determine the seed production potential of selected forage species;
• Research agronomic practices for optimum seed production of improved forage crops;
• Determine the seed storage shelf-life and quality parameters for pasture and forage crops;
• Design and develop formal forage seed production schemes; and
• Develop the manpower and skills for forage seed research in the region

References

Forage Seed Research and Production in Oromia Agricultural Research Institute

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Introduction

The Oromia region is diverse in its agro-ecology and endowed with a wealth of indigenous livestock species. In most agro-ecologies, livestock are an integral part of the production system and play an important role in the small-scale farming systems of the region. Inadequate nutrition is the main constraint to increase livestock production and productivity. In the past communal grazing on the natural pasture was the most important ruminant livestock feed resource in most agro-ecological areas. Currently, the quantity and quality of feeds available from natural pastures is very low due to overgrazing, erosion and overall land degradation. In addition, in most highland agro-ecologies of the region, the increasing human population, with subsequent increase in land used for crop production has resulted in reduction of existing grazing areas. In cereal crop dominated areas, crop residues are used as the major livestock feed resource even though their nutritional value is very low (Zinash and Seyoum, 1991). This suggests there is a need for feed resource technology development and transfer that aimed at improving the quantity and quality of feed resources in the region.

One of the options to improve feed availability and quality is through cultivating improved forage and pasture. Even though productive cultivated forage crops have been recommended for the different agro-ecologies and production systems, their utilization at farmers’ level is minimal, mainly due to shortage of planting materials and poor extension activities. Ensuring forage seed/planting material availability is an important step in successful improved forage technology demonstration, scaling up/out (Alemayehu, 1997). Producing forage seeds locally is economical and ensures sustainability. This paper provides an overview of the major research efforts made by the research centers of the Oromia Agricultural Research Institute on improved forage seed production and promotion techniques and cultural practices that can improve seed yield and quality of different forage species.

Achievements on Forage Seed Research

A considerable number of annual and perennial forage species were tested and some productive grasses, herbaceous legumes and tree legumes have been selected
and recommended for the different agro-ecological zones of Oromia (Table 1). However, the expansion and utilization of these improved forages by the end users is very low, mainly due to inadequate supply of good quality seed and planting materials. In order to improve forage seed yield and quality and to ensure a sustainable seed supply, seed research and development activities in the region were carried out by Bako, Adami Tulu, Sinana and by some other recently established research centers.

Most of the tested and selected forage species well adapted to the different agro-ecologies. However, some of grasses and legumes showed problems of low seed yield and quality. This may be due to management resulting from inadequate information on optimum seed rate, season of establishment, harvesting time, problem of uneven seed maturity and seed shattering. Seed production methods for forage crops are quite different from those used for cereal crops. Each herbage plant is different and it is important to know the proper sowing rate, method of seeding and the best stage of maturity for seed harvest.

Seed production of perennial grasses is difficult because ripe seed may shed easily and rapidly. Flower spikes appear gradually and when some tillers have ripe seed, others have only begun to flower (Bogdan, 1977). Information on seed rate and proportions of different species in mixtures is crucial to maximize productivity. Various experiments were conducted at Oromia regional research centers to improve the seed yield and quality of adapted forage species.

**Perennial grasses**

The optimum seed rate and season of establishment for seed production of *Phalaris aquatica* was determined using four seed rates (5, 10, 15 and 20 kg/ha) and four row spacing (20, 30, 40 cm and broadcasting). Establishment of phalaris grass in the ‘Belg’ (March to July) season resulted in higher total seed yield compared to seed yield of the ‘Meher’ grass establishment season. However, in both seasons, higher seed yield and uniform heads were observed when sown at a seed rate of 10 kg/ha with a spacing of 40 cm (Tekleyohannes et al., 2004).

An experiment conducted to determine the optimum establishment season and time of seed harvest of *Chloris gayana* and *Panicum coloratum* indicated a difference in seed yield between the ‘Belg’ and ‘Meher’ grass establishment seasons. Average seed yields of 370.3 and 168.5 kg/ha were produced from *C. gayana*, 127.1, and 122.4 kg/ha from *P. coloratum* from the ‘Belg’ and ‘Meher’ season of establishment, respectively. Perennial forage grasses such as *C. gayana*, *P. coloratum* and *P. aquatica* could produce higher seed yields if established in the ‘Belg’ season in the highland of Bale.
Table 1. Selected promising improved forage species for different agro-ecological zones

<table>
<thead>
<tr>
<th>Forage crops</th>
<th>High altitude (&gt;1800m)</th>
<th>Low to medium altitude (1000 - 1800m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasses</td>
<td>Oats (Cl-8237, Cl-8251) Phalaris aquatica Chloris gayana Panicum coloratum Pennisetum purpureum</td>
<td>Oats (Jassari, Lampton) Chloris gayana Panicum coloratum Pennisetum purpureum Sorghum sudanense Sorghum almum Setaria sphacelata</td>
</tr>
<tr>
<td>Herbaceous legumes</td>
<td>Vicia spp Trifolium spp Medicago sativa (alfalfa) Melilotus spp</td>
<td>Vicia spp Lotus corniculatus Medicago sativa (alfalfa) Desmodium spp Stylosanthes spp Lablab purpureus</td>
</tr>
<tr>
<td>Tree legumes</td>
<td>Chamaecytisus palmensis Sesbania sesban</td>
<td>Leucaena leucocephala Chamaecytisus palmensis Sesbania sesban Cajanus cajan</td>
</tr>
<tr>
<td>Root crops</td>
<td>Fodder beet</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Archive of Adami Tulu, Sinana and Bako Research Center (1994-2010)

Tekleyohannes et al. (2004) also suggested that optimum time of seed harvest for maximum seed yield of *C. gayana* and *P. coloratum* could be obtained when harvested between 30-60 days after full heading (DAFH) for ‘Belg’ established grasses. For grasses established in the ‘Meher’ season, the optimum time of seed harvest was 10-30 DAFH. The dry weather at the end of ‘Meher’ season could result in high seed shattering for late harvests. Seed germination tests showed that *C. gayana* and *P. coloratum* recorded a germination of 54.8% and 49.7% for *Chloris gayana* and 10.1% and 23.0 % for *P. coloratum* for the ‘Belg’ and ‘Meher’ seasons respectively (Tekleyohannes et al., 2004). In both seasons, early harvesting (10-20 DAFH) of the grasses resulted in lower seed germination (Table 2).

**Herbaceous forage legumes**

Optimum sowing time and seed rate for maximum seed yield production were also determined for alfalfa variety *Hunter River* in a trial at Sinana. Four sowing times (mid August and 10, 20 and 30 days after the first sowing) and three seed rates (5, 10 and15 kg/ha) were tested. The results indicated that as sowing times delayed and seed rate increased, there was a negative trend in seed yield (Fig 5 and 6). Sowing alfalfa at the normal time (at the onset of rainfall for the *Meher*
season) at the minimum seeding rate (5 kg/ha) produced higher seed yield (118.8 kg/ha) allowing quick establishment and exploitation of the long growing season (SARC 2005).

Table 2. Percent seed germination of *Chloris gayana & Panicum coloratum* sown during the 'Belg' and 'Meher' seasons of 1997.

<table>
<thead>
<tr>
<th>Time of seed harvest (DAFH)</th>
<th><em>Chloris gayana</em></th>
<th><em>Panicum coloratum</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Belg</em> (1st harvest)</td>
<td><em>Meher</em> (1st harvest)</td>
</tr>
<tr>
<td>10</td>
<td>45.3c</td>
<td>40.5c</td>
</tr>
<tr>
<td>20</td>
<td>59.2ab</td>
<td>30.4d</td>
</tr>
<tr>
<td>30</td>
<td>56.3b</td>
<td>68.6ab</td>
</tr>
<tr>
<td>40</td>
<td>63.5a</td>
<td>23.9d</td>
</tr>
<tr>
<td>50</td>
<td>63.8a</td>
<td>72.2a</td>
</tr>
<tr>
<td>60</td>
<td>40.5c</td>
<td>62.5b</td>
</tr>
<tr>
<td>Mean</td>
<td>54.8</td>
<td>49.7</td>
</tr>
<tr>
<td>LSD</td>
<td>6.475</td>
<td>7.55</td>
</tr>
<tr>
<td>CV %</td>
<td>14.38</td>
<td>18.51</td>
</tr>
</tbody>
</table>

DAFH= Days after full heading of the grass; LSD= Least significant difference, NS= Non Significant (P>0.05); ‘Belg’= March to July; ‘Meher’= July to December

Similarly, four adapted vetch were evaluated using five seeding rates to determine optimum seed rate and season of sowing. All vetch varieties gave higher seed yield at the seed rate of 20 kg/ha in the 'Belg' season than in the 'Meher' season except *V. atropurpurea* (Table 3). *V. Sativa* (14.85 q/ha) and *V. atropurpurea* (11.01q/ha) produced the highest seed yield followed by *V. dasycarpa* (8.7 q/ha) (SARC 2004).

**Forage Seed Production and Dissemination**

Identification of improved forage species and recommendation of different technologies has been made for the different agro-ecologies of the region. This has resulted in an increasing demand for improved forage production. To satisfy this demand, a reliable source of seed/vegetative material of recommended species is crucial. However, forage seed production and dissemination activities have received little attention and the majority of forage crops have not been widely adopted by farmers. Although seeds/planting materials of improved forage varieties, including forage legumes, perennial grasses, elephant grass and fodder oats, have been produced and disseminated (Table 4), the supply of seed/planting material is the primary constraint to increased used of forages in the region. Different varieties of forage seeds have been provided to farmers for
cultivation. A maximum of 1 kg seed of forage species, especially oats, are provided free of charge and farmers and non-governmental organizations requiring a larger quantity of seeds may buy them at the price set by the center.

Table 3. Effect of species and seed rate on mean seed yields (q/ha) of vetch

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Seeding rate (kg/ha)</th>
<th>Seasonal seed yield (q/ha)</th>
<th>Mean seed yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>‘Belg’</td>
<td>‘Meher’</td>
</tr>
<tr>
<td><em>Vicia dasycarpa</em></td>
<td>10</td>
<td>11.41</td>
<td>7.26</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>11.35</td>
<td>7.99</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>10.60</td>
<td>7.28</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>8.31</td>
<td>7.86</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>7.83</td>
<td>6.38</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>10.0</td>
<td>7.40</td>
</tr>
<tr>
<td><em>Vicia sativa</em></td>
<td>10</td>
<td>13.70</td>
<td>9.09</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>18.11</td>
<td>12.01</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>17.54</td>
<td>11.61</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>17.66</td>
<td>10.05</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>17.05</td>
<td>10.06</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>17.70</td>
<td>12.00</td>
</tr>
<tr>
<td><em>Vicia atropurpurea</em></td>
<td>10</td>
<td>11.11</td>
<td>10.88</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>14.22</td>
<td>13.81</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>9.42</td>
<td>12.76</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>7.42</td>
<td>12.67</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>5.99</td>
<td>11.81</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>9.63</td>
<td>12.30</td>
</tr>
<tr>
<td><em>Vicia sativa</em></td>
<td>10</td>
<td>6.43</td>
<td>1.90</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>6.21</td>
<td>3.61</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>6.16</td>
<td>3.10</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>5.10</td>
<td>2.51</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>5.71</td>
<td>2.81</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>5.92</td>
<td>2.80</td>
</tr>
</tbody>
</table>
Farmers participatory forage seed production and dissemination activities were also carried out in farmer’s fields of two farmers research group (FRG) in Sinana. The main objectives were participatory evaluation of forage crops for their herbage and seed yield performance and to increase seed availability and dissemination (Table 5). Accordingly, every farmer planted improved forage crops species of vetch, alfalfa and fodder oats on an area of 600 m². Farmers were involved in forage crop management from land preparation to harvesting. The planting materials with their relevant agronomic practices were introduced to the group of farmers and farmers evaluated the varieties and shared their views regarding the varieties. Except alfalfa varieties, which produced low seed yield, oats and vetch had higher seed yield. Farmers made agreements to repay the amount of starter forage seed. The collected seed was used further dissemination and scaling up to other farmers.

Similar efforts on community based forage seed multiplication activities have been also undertaken by Mechara, Fedis, and Bore Research Centers with the main aim to disseminate the technology and increase forage seed availability. Adapted improved forage crops have been multiplied and evaluated at selected farmers fields and Farmers training centers (FTCs) using this farmer participatory approach.

Table 5. Forage seed produced and redistributed for the farmer groups

<table>
<thead>
<tr>
<th>Forage varieties</th>
<th>Seed yield (kg)</th>
<th>Amount of seeds distributed per farmer (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fodder oat</td>
<td>250.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Vetch</td>
<td>48.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>5.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Total</td>
<td>303.8</td>
<td>3.4</td>
</tr>
</tbody>
</table>
Limitations of Forage Seed Research and Production

The low productivity and degradation of natural pastures has resulted in feed shortages throughout the year. Research and development to improve the productivity and degradation of natural pastures is insignificant in the region and research on the growth dynamics and seed germination potential of native forage species is important to improve the quantity and quality of the pasture. The adoption and utilization of improved forage crops could provide an alternative solution to feed shortages, but is limited mainly due to absence of adequate amounts of planting materials. Forage seed yield, seed quality and post harvest processing have not been extensively investigated in the region. The major management problems encountered in forage seed production include uneven ripening of seed, seed shattering/shedding and accurate timing of seed harvests.

In some areas, including the highlands of Bale, the demand for forage seed by smallholder farmers is increasing but is not being matched with seed production in the region. Most of this increased demand comes from small scale farmers through development agents of the District Agricultural Offices. Absence of forage seed producing organizations is a limitation for forage development in the region. Research centers have been involved in seed production but only produce small amounts of seeds, usually on less than 1 hectare for research and basic seed provision.

There are limited opportunities for training in forage seed production, handling and marketing in Ethiopia. Research, training and outreach activities can improve the uniformity of seed standards and procedures and increase the flow of germplasm among the research centers. However, such activities are very minimal due to poor linkages among the research centers, governmental and non-governmental organizations in the country. The marketing system of forage seeds is not well developed and fluctuating in demand and price, which is a high risk and discourages entrepreneurs to enter the commercial forage seed production.

Conclusions and Recommendations

Development activities related to forage seed production, distribution and promotion have been given little attention. Research centers are producing and distributing improved forage seeds/planting materials, but quantities are low and the majority of varieties have not reached many farmers in the region. Research is needed on management techniques to assure forage seed yield and quality, including site identification, growth and flowering patterns and efficient
harvesting and post harvest practices. Forage seed production by farmers is primarily aimed to maintain seed for the next cropping season rather than for marketing. Although there is high and recurring demand for forage seeds, the governmental, non-governmental and private sector institutions involved in improved food crop seed production are rarely involved in forage seed production and there is no well organized market system for forage seeds in the region.

Detailed studies on the agronomic and cultural practices that can increase seed yields of different forage crops are required to increase seed availability. Government and non-government organizations should be strengthened to produce forage and pasture seeds to satisfy the demand by farmers. Research centers should produce breeder and basic seeds and maintain vegetatively propagated forage materials for further research and dissemination activities. In order to encourage rural farmers to use improved forages, the government should provide the farmers with inputs such as initial seed of improved forage varieties and technical information (full packages). A more thorough approach to the problem of forage seed scarcity should also include training.

Diverse actors should work together in platforms to foster innovations in livestock production, particularly to link livestock producers with markets. The roles and responsibilities of each partner in forage seed production should be clearly delineated and organizations with experience need to play a leadership role to encourage adoption of innovations. Farmers could also be organized into cooperatives and linked with seed markets to increase forage seed supply in the region. There is a need to increase efforts of domestic seed production through training, exchange of germplasm and access to knowledge. Information on forage seed production, including manuals, pamphlets and brochures should be targeted to the end users.

References

Forage Seed Research and Development in Somali Regional State

Muhyadin Mohammed
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Introduction

In pastoral areas of Somali Regional State (SRS) environmental degradation, water scarcity, increasing human and livestock population, and expansion of crop cultivation have contributed to a reduction in the quantity and quality of productive rangeland. Moreover, there is a marked seasonality in the quantity and quality of feed available. In the wet season, the community used to have enough fodder available to feed their livestock. Increasing resource base shrinkage due to farm encroachment and land degradation has minimized this prospect making feed shortage the reality of the wet season too. In the dry season, the challenge is severe. The meager amount of forage available is characterized by low protein and high fiber content causing a drop in weight and milk production. These factors combined with poor animal and human health, place enormous stress on the traditional pastoral and land management practices. As a result the productivity and economic contribution of the huge livestock population do not definitely much their number.

As part of its effort to address feed shortage, Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI) introduced and tested the adaptability of numerous promising forage species. To this effect, different promising grass and legume species have been identified for both the arid and semi arid agro-ecologies of the region. Essentially, the development and use of improved technology is a key factor in the promotion of increased production and productivity in the Somali region and in the country as well. Therefore, this paper highlights the adopted improved forage technologies including the forage seed production and their impacts on the livelihood of pastoral and agro-pastoral community. Moreover, opportunities and challenges in using the improved forage technologies in SRS have been highlighted.
**Accomplishments**

**Improved forage grasses and legumes tested**
Most palatable forage plants are becoming limited because of the rangeland degradation and over grazing resulting in a shortage of plants. This is further aggravated by deterioration of the range ecology and the ever-escalating human and livestock population. The livelihood of pastoralists and agro-pastoralists of the SRS is dependent on livestock and livestock products. However, the livestock production is highly constrained by shortage of feed caused by frequent drought which affected both feed quality and quantities. The few feed resources available are very poor and can’t meet the feed requirement of the livestock leading to low productivity.

In order to alleviate the feed shortage problem in the SRS, SoRPARI introduced various improved forage legumes and grasses into the region. Different forage varieties were planted into two different agro-ecologies (rain fed and irrigated areas). These are namely, elephant grass, dolichos lablab, *Leucaena leucocephala*, *Sesbania sesban*, cowpea small/large, buffle grass, *Panicum maximum*, Sudan grass, *Panicum antidotale*, desmodium, siratro, and alfalfa. The general goal of introducing improved forages was development of improved forage crops and their management practices and providing sustainable supply of quality forage seeds. Some of the selected forage technologies were transferred for the benefit of farmer’s research groups to undertake community based seed production. These varieties were transferred to agro-pastoralists’ field located along Shebelle river of Gode Zone, Weyb River of Afder Zone, Genale River of Liban Zone, JigJiga Zone and Shinile Zone through Participatory Variety Selection (PVS). The adapted forage varieties include dolichos lablab, *Panicum maximum*, *Panicum antidotale*, buffle grass, Sudan grass, and elephant grass. Accordingly, the air dry matter weight yield of cowpea small, cowpea large and alfalfa (from planting to initial cut) were found to be 6.10, 5.09 and 1.58 t/ha and that of Sudan grass, buffle grass, rhodes grass, and *Panicum maximum* were 7.99, 7.56, 7.43 and 4.34 t/ha, respectively. Therefore, among the legumes and grasses, cowpea small /large and Sudan grass gave the highest DM yield at first harvest, i.e., 6.10 and 7.99 t/ha, respectively.

**Impact of introduced improved forage seeds**
Research centers and sub centers of SoRPARI have conducted various adaptability trials and those forage species found to perform better under respective agro-ecological conditions have been disseminated to community via farmer’s research groups, cooperatives, and individual agro-pastoralists. The major forage species introduced to the community include rhodes grass, elephant grass, Sudan grass, *Panicum maximum*, buffle grass, cowpea large/small, dolichos lablab, alfalfa, and *Leucaena leucocephala*. The performance of Sudan grass has attracted special attention of the end users. Sudan grass become
popular because of the relative ease of collecting its seed compared to other grass species.

Improved forage species which have been introduced to the community have benefited the community in a number of ways. There is significant income increase from the sale of forage seeds and hay. For instance, Masno, one of the FRGs of Gode alone got more than 45,400.00 Birr from the sale of forage seed and hay in October and April growing seasons (Table 1). Similarly, Qudader, another FRG of Gode, was able to get more than 33,400.00 Birr in similar seasons. An individual agro-pastoralist from Fafen area has been able to sale 3 kg of Sudan grass for 750.00 Birr, which worth more than a quintal of some cereals. These specific figures and examples show how profitable the forage seed production can be, which have been positively perceived by interviewed pastoral and agro-pastoral beneficiaries of the region.

Table 1. Forage seeds produced and income generated by Gode, Jigjiga, and Gursum Farmer's Research Groups (FRG)

<table>
<thead>
<tr>
<th>FRG</th>
<th>Harvesting months</th>
<th>Forage type</th>
<th>Cultivated Area (ha)</th>
<th>Income (birr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masno</td>
<td>October</td>
<td>Sudan grass</td>
<td>2</td>
<td>24,400.00</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>Sudan grass</td>
<td>3</td>
<td>21,000</td>
</tr>
<tr>
<td>Qudader</td>
<td>October</td>
<td>Sudan grass, Cow pea</td>
<td>2, 0.5</td>
<td>33,400.00</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>Sudan grass</td>
<td>3</td>
<td>21,000.00</td>
</tr>
<tr>
<td>Horahad</td>
<td>July</td>
<td>Sudan grass</td>
<td>1</td>
<td>50,000.00</td>
</tr>
<tr>
<td>Horseed</td>
<td>July</td>
<td>Buffle and panicum grasses</td>
<td>1</td>
<td>30,000.00</td>
</tr>
</tbody>
</table>

Source: SoRPARI, 2005/06.

Ethiopian dry lands are characterized by frequent drought and unpredictable rainfall. This has created a boom and bust type of livestock population, a livestock population which increases when ample rainfall is available, but declines dramatically during shortages. In the past, Somali pastoralists used mobility, a periodic movement to overcome this challenge. Increased human population decreased individual livestock holding, worsening land degradation and expanding farm encroachment has minimized the prospect of mobility causing a dramatic change in lifestyle of pastoralists. As a result, the impact of drought and its frequency has worsened in the past decade and weakened the economy of pastoral and agro-pastoral community of the region.
Introduced forage grasses and legumes have better productivity and nutritive value. Key informants/beneficiaries of improved forage seeds have stressed the key role of these improved forage species in saving their livestock from drought. Most of the beneficiaries agreed that the productivity of their livestock in terms of milk and meat has practically improved and contributed to the betterment of their livelihoods. A minimum of 300 individuals have participated and benefited from the dissemination of improved forage seeds at each research centers of SRS. The figure could be higher than this, as we have considered only those individuals who have received forage seeds from the research centers and sub centers of the Institute. In addition to this, more members of agro-pastoralists have received and used improved forage seeds from their neighbors, relatives and from FRGs.

**Opportunities**

- Excellent environment for forage production such as plenty of land and water resources as well as sunshine and warm temperature. For instance, the Wabi Shebelle river is a “Gold Mine” waiting to be exploited in terms of forage and crop production. In line with this, measures have been started to change the Wabi Shebelle river potential into something useful;
- There is a huge potential and an opportunity waiting to be grabbed for making the SRS self sufficient in animal feed production and even exporting to neighboring regions and other states found nearby;
- Improved forage seed multiplication and emergency feed supply project are underway jointly by SoRPARI and the pastoral community development project (PCDP);
- Appropriate production technology that is adopted by agro-pastoralists already available; and
- Best forage legume and grass species and/or varieties have been tested, selected, multiplied, and diffused. SoRPARI has supported agro-pastoralists in the selection and evaluation of improved forage varieties implying the availability of know-how in the area. As such distribution of forage seeds and training on farm management has been done before.

**Challenges**

- Poor adoption of improved forage grass and legume seed technologies;
- Lack of improved forage seeds at the local market except few seeds produced by the FRGs, cooperatives and research centers and sub centers of the region;
- Lack of private investors who take part in the forage seed business of the country in general and Somali region in particular; and
- Unreliable market for the improved forage seeds produced by the FRGs, cooperatives, and individual agro-pastoralists engaged in forage production.
Conclusion and Recommendation

Conservation of rangeland or natural grazing land and animal feeds development are considered as key interventions to ensure food security in the drought affected areas. The contribution of introduced improved forage seeds in saving livestock population and improving the livelihood of the community has been tremendous and encouraging for future interventions. Large scale improved forage seed production in the irrigated areas of the region will definitely improve the feed shortage problem and consequently the production and productivity of livestock of the region. As such there is a need for further promotion of forage seed producer farmer's research groups and cooperatives in selected areas where demand for improved forage seed is high and the environment is convenient for seed production. Agro-pastoralists may be organized into cooperatives whereby they pool their land on which they produce seeds of elite forage crops and sell to users elsewhere. Seed production, maintenance, and development are important ventures for the promotion of improved pasture and forage crops.

References

On-Station and Community-Based Forage Seed Production in the Southern Region of Ethiopia

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Introduction

Feed shortages are among the major impediments for increasing livestock production and productivity in general and market-oriented livestock production in particular (Berhanu et al., 2008). A preliminary study on problem identification of the farming system indicated that addressing the feed shortage is a priority research thematic area for the region (SARI, 2009). Long-term sustainable production of livestock and cropping is dependent on dramatic changes in livestock management systems (Alemayehu and Alan, 1998).

Getnet (2003) described the suitability of forage species and their seed production potential for different agro-ecological zones of the country. The South Region is endowed with different agro-ecological zones suitable for forage production. Improved forage species have already been introduced to urban and peri-urban areas with potential for livestock production and marketing.

Small-scale production of forage seed is important as a back-up to provide seed for research, further seed multiplication and forage production. Forage adoption requires a reliable source of seed or vegetative material of species recommended and adapted for the area (ILCA, 1994) and problems of seed supply often follow the initial success of forage introduction and promotion. There is no single system of seed production suited to the varying social or environmental situations in sub-Saharan Africa as forages are not widely sown as crops in sub-Saharan Africa and market demand for high quality uniform seeds is low.

Methodology

Preliminary forage biomass and seed production and adaptability research was carried out at the Mante Dubo experimental site of the Areka Agricultural Research Centre. The site is located at an altitude of 1711 masl and situated at 7°06.4312'N latitude and 37°41.688'E longitude. Production of forage seeds and
vegetative cuttings were established in 2008 during the introduction of Dorper sheep as part of the establishment of breeding, evaluation and distribution (BED) activities to improve mutton yield of local sheep.

Primary data from participatory evaluation of community-based forage seed production and secondary data (published and unpublished sources) on seed collection and dissemination in Soddo, Durame and Hosanna areas were also considered for the review to identify the extent of acceptance of farmers for forage seed or vegetative material. Hawassa Agricultural Research Centre (ARC) carried out research at Shebe-dino, Inseno and Hawassa Zuria on community-based forage biomass and seed production and results from this work were reviewed. Secondary data were reviewed from forage production potential areas including Soddo Zuria, Kedida Gamela and Lemo (Hossana Zuria) woredas. Private agencies and non-governmental organizations involved in seed production or supply and dissemination were also contacted to determine the seed dissemination and marketing pathways.

**On-station forage seed production**

The Dubo Mante site of the Areka Agricultural Research Centre is an ideal site for research on forage biomass and seed production. Initially the objectives of the forage production unit were to produce production packages covering breed, health and forage components. Although the forage species established on-station was targeted primarily to improve biomass production, some plots were reserved to collect seed from commonly produced species. Preliminary studies on seed yield indicated that most forage species gave reasonable yield in the study area (Table 1). The lower seed yield in some species may be related with their poor adaptability in the area. Most of the improved forage species can adapt well and set seed under Areka conditions.

The results from preliminary on-station seed multiplication plots demonstrated that seed multiplication for the multi-range of forage species (grasses and legumes) is feasible, using available inputs. ‘Desho’ grass had the highest demand and its distribution increased from 100,000 in 2009 to 450,000 root splits in 2010 (Table 2). Desho grass is disseminated by root splits and can easily be established. Rainfall distribution was good in 2010, which contributed to the successful multiplication and dissemination of the grass.

Although the seed demand increased for all forage species, the increment was gradual for annuals. Rather, there is high interest and demand for perennial forages and vegetative plant materials than seeds as most of the users and stakeholders are requesting planting materials of perennial grasses (Napier and ‘Desho’).
Table 1. Yields from Dubo on-station forage seed and planting material multiplication plots

<table>
<thead>
<tr>
<th>Species</th>
<th>Seed yield (kg/ha)</th>
<th>2009</th>
<th>2010</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sesbania sesban</td>
<td></td>
<td>16</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>Lupinus albus</td>
<td></td>
<td>500</td>
<td>570</td>
<td>535</td>
</tr>
<tr>
<td>Desmodium intortum</td>
<td></td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Chloris gayana</td>
<td></td>
<td>64</td>
<td>80</td>
<td>72</td>
</tr>
<tr>
<td>Lablab purpureus</td>
<td></td>
<td>512</td>
<td>625</td>
<td>569</td>
</tr>
<tr>
<td>Avena sativa (CI-8235)</td>
<td></td>
<td>580</td>
<td>750</td>
<td>665</td>
</tr>
<tr>
<td>Vicia dasycarpa</td>
<td></td>
<td>144</td>
<td>220</td>
<td>182</td>
</tr>
<tr>
<td>Vigna unguiculata (Cow pea) ITRD-716</td>
<td></td>
<td>194</td>
<td>200</td>
<td>197</td>
</tr>
<tr>
<td>Pennisetum purpureus 16798</td>
<td>Ne*</td>
<td>Ne</td>
<td>Ne</td>
<td>-</td>
</tr>
<tr>
<td>'Desho' grass</td>
<td></td>
<td>Ne</td>
<td>Ne</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Dubo on-station research reports; *Ne = not estimated

Table 2. Forage seed and vegetative parts distribution in year 2009 to 2010 from Areka Research Center

<table>
<thead>
<tr>
<th>Forage species</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sesbania sesban</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>Lupinus albus</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>Desmodium intortum</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Chloris gayana</td>
<td>30</td>
<td>56</td>
</tr>
<tr>
<td>Lablab purpureus</td>
<td>20</td>
<td>46</td>
</tr>
<tr>
<td>Avena sativa (CI-8237)</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Vicia dasycarpa</td>
<td>-</td>
<td>28</td>
</tr>
<tr>
<td>Vigna unguiculata (Cow pea –IT86D-716)</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Pennisetum purpureus (ILRI-14694) *</td>
<td>7,500</td>
<td>8000</td>
</tr>
<tr>
<td>'Desho' grass*</td>
<td>100,000</td>
<td>45,000</td>
</tr>
</tbody>
</table>

Source: Dubo on-station research reports; * root splits/cuttings,**distributed in the Ojoje watershed
Community-based forage seed production

Farmer participatory seed production: A summary of yield of forage seeds at different woredas of SNNPR is presented in Table 3. The results indicated that a mean yield of 171.4, 37.5 and 175.0 kg /ha seed was reported for *Chloris gayana*, *Medicago sativa* and *Panicum coloratum* respectively, from community based forage seed production. As farmers had no experience of using fertilizers for forage production, the results obtained are similar compared with other on-farm studies. Furthermore, they allocated marginalized lands for forage crops which otherwise would not been allocated for food crops. There is some resistance from farmers to sow or plant forages on cultivable lands, mainly associated to land shortage in the area. However, those farmers generating income mainly from livestock production are more flexible and focusing on them will make dissemination efforts more successful.

Napier grass had the highest DM yield (11.1 and 12.6 t/ha for accession number 16800 and 16798, respectively), whereas *Medicago sativa* had the least (Table 4). Biomass yield is the determining factor for the forage species to be accepted or rejected by the beneficiaries. Farmers awareness on forage biomass and seed production was increased during the community based work and they were involved at all stages of the research and development process, including participatory planning, problem prioritizing, implementation and evaluation. The results indicated the great diversity in forage grass and legume species that are suitable for forage and seed production in the lowland and mid-altitudinal areas of the region.

Table 3. Mean seed yield (kg/ha) of *Chloris gayana* *Medicago sativa* *Panicum coloratum* at selected woredas of southern region.

<table>
<thead>
<tr>
<th>Location</th>
<th><em>Chloris gayana</em></th>
<th><em>Medicago sativa</em></th>
<th><em>Panicum coloratum</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2003</td>
<td>2004</td>
<td>Mean</td>
</tr>
<tr>
<td>Shebedino</td>
<td>156</td>
<td>192</td>
<td>174</td>
</tr>
<tr>
<td>Hawassa</td>
<td>197</td>
<td>192</td>
<td>195</td>
</tr>
<tr>
<td>Inseno</td>
<td>137</td>
<td>154</td>
<td>145</td>
</tr>
<tr>
<td>Mean</td>
<td>163</td>
<td>179</td>
<td>171</td>
</tr>
</tbody>
</table>

Source: Hawassa Agricultural Research Centre Progress Reports, 2005

Forage seeds production and distribution: Wolitta, Kembata tembaro and Hadiya zones are known for their high human population pressure. The dominant farming system is mixed crop-livestock and crop and livestock production complement each other. In these areas, crop residues are used as the major feed resource due to land shortages. However, crop residues are poor in
their nutritive value and need to be supplemented. The Fourth Livestock Development Project (FLDP), Smallholder Dairy Development Project (SDDP) and the National Livestock Development Project (NLDP) introduced many forage species. Adoption of improved forages was better in urban and peri-urban areas, which have better market outlets for the dairy products. The interventions by FLDP, SDDP and NLDP increased the knowledge and skills of farmers on the use of improved forages, forage seed production, and used individual farmers and government nurseries for multiplication and seed production. The approach in FLDP was to establish a large forage seed production and carry out the research needed to support the programme.

Table 4. Dry matter yield of best-adapted forage crops at different selected woredas of southern region

<table>
<thead>
<tr>
<th>Forage species</th>
<th>DM yield (t/ha) at selected woredas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shebdino</td>
</tr>
<tr>
<td>Napier grass - 16800</td>
<td>8.0</td>
</tr>
<tr>
<td>Napier grass - 16798</td>
<td>10.7</td>
</tr>
<tr>
<td>Chloris gayana</td>
<td>6.6</td>
</tr>
<tr>
<td>Medicago sativa</td>
<td>3.2</td>
</tr>
<tr>
<td>Desmodium intortum</td>
<td>3.9</td>
</tr>
<tr>
<td>Vigna unguiculata</td>
<td>3.6</td>
</tr>
<tr>
<td>Lablab purpureus</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Source: Hawassa Agricultural Research Centre Progress Reports, 2005

A summary of the forage species (grasses and legumes) seed distribution to various sites of Soddo Zuria and Kedida Gamela district is presented in Tables 5 and 6. Soddo Zuria and Kedida Gamela woredas are potential areas for high grade and crossbred animals. As a result, farmers have experience in forage and seed production. The indicator in Soddo Zuria is the number of farmers growing forages (n=56 in year 2006 to n=120 in year 2010) due to increased numbers of crossbred animals and awareness for improved livestock and forage management. Reports from both districts indicated that breed improvement and emerging markets for animal products further contributed to the increased forage production, especially for vegetative propagating forage species. Reports show that some farmers are innovative and are developing agri-businesses in the sale of forage seeds. A model farmer, Bolticho Onu in Damot Sore Woreda sold 50m³ Napier, 30m³ ‘Desho’ grass root splits and 10 kg Disodium seed with an income of 4500 Ethiopian birr in the year 2009. This farmer expanded his
forage planting, seed production in the backyard as a live fence, and used intercropping after obtaining planting materials from his colleagues, friends and the Woreda office of agriculture and Action for Development (NGO). This implies that some farmers are innovative and generating income from sale of forage seeds and vegetative planting materials.

Farmers of Kedida Gamela Woreda suggested that it is better to focus on vegetative propagating forage types which could be produced in different niches on the farm rather than competing for cropping lands because of land shortage for food crop production in the area. They identified appropriate niches as soil and water conservation barriers, backyards, farm boundaries and fences. Soil and water conservation structures are considered the most appropriate niches to maximize the benefits of planted forages. The review results indicated that most of the forage species are adapted to the mid agro-ecological zones of the central Southern region. Farmers with high grade and crossbreed animals showed a greater interest in these forage species due to the higher biomass yield obtained and the availability of green fodder in the extreme dry season.

Table 5. Forage seed (kg) and vegetative parts (numbers) distributed to farmers in Soddo Zuria, Wolitta Zone

<table>
<thead>
<tr>
<th>Forage species</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>Mean</th>
<th>Farmers acceptance</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Lablab purpureus</em></td>
<td>180</td>
<td>555</td>
<td>250</td>
<td>200</td>
<td>50</td>
<td>247</td>
<td>Good</td>
</tr>
<tr>
<td><em>Avena sativa</em></td>
<td>550</td>
<td>1783</td>
<td>150</td>
<td>120</td>
<td>100</td>
<td>541</td>
<td>Variable</td>
</tr>
<tr>
<td><em>Chloris gayana</em></td>
<td>2</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>Good</td>
</tr>
<tr>
<td><em>Napier cuttings</em></td>
<td>-</td>
<td>750</td>
<td>200</td>
<td>300</td>
<td>500</td>
<td>350</td>
<td>Very good</td>
</tr>
<tr>
<td><em>‘Desho’ grass</em></td>
<td>-</td>
<td>-</td>
<td>150</td>
<td>200</td>
<td>150</td>
<td>100</td>
<td>Very good</td>
</tr>
<tr>
<td><em>Sesbania sesban</em></td>
<td>2</td>
<td>47</td>
<td>47</td>
<td>50</td>
<td>30</td>
<td>35</td>
<td>Good</td>
</tr>
<tr>
<td><em>Vicia species</em></td>
<td>20</td>
<td>50</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>14</td>
<td>Low</td>
</tr>
<tr>
<td><em>Fodder beet</em></td>
<td>134</td>
<td>200</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>67</td>
<td>Variable</td>
</tr>
<tr>
<td><em>Pigeon pea</em></td>
<td>4</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>Good</td>
</tr>
<tr>
<td><em>Tree Lucerne</em></td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.4</td>
<td>Good</td>
</tr>
<tr>
<td>No of beneficiaries</td>
<td>56</td>
<td>60</td>
<td>75</td>
<td>87</td>
<td>120</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Wolitta zone, Soddo zuria BOA, 2011.* - *root splits in thousands*
Table 6. Forage seed distribution for farmers in Kedida Gamela woreda, Kembata Tembaro Zone

<table>
<thead>
<tr>
<th>Forage species</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>Mean</th>
<th>Farmers Acceptance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass species</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lablab purpureus</td>
<td>15</td>
<td>37</td>
<td>14</td>
<td>50</td>
<td>21</td>
<td>27</td>
<td>Good</td>
</tr>
<tr>
<td>Avena sativa</td>
<td>28</td>
<td>83</td>
<td>23</td>
<td>60</td>
<td>179</td>
<td>75</td>
<td>Low</td>
</tr>
<tr>
<td>Chloris gayana</td>
<td>11</td>
<td>28</td>
<td>12</td>
<td>33</td>
<td>53</td>
<td>27</td>
<td>Good</td>
</tr>
<tr>
<td>‘Desho’ grass *</td>
<td>150</td>
<td>200</td>
<td>220</td>
<td>250</td>
<td>280</td>
<td>220</td>
<td>Excellent</td>
</tr>
<tr>
<td>Napier grass**</td>
<td>200</td>
<td>180</td>
<td>350</td>
<td>400</td>
<td>750</td>
<td>364</td>
<td>Very good</td>
</tr>
<tr>
<td>Siratro</td>
<td>-</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Root crops</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fodder beet</td>
<td>3</td>
<td>26</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>8</td>
<td>Variable</td>
</tr>
<tr>
<td>Legume species</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicia species</td>
<td>23</td>
<td>38</td>
<td>13</td>
<td>8</td>
<td>28</td>
<td>22</td>
<td>Variable</td>
</tr>
<tr>
<td>Sesbania sesban</td>
<td>19</td>
<td>25</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>11</td>
<td>Very good</td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>6</td>
<td>30</td>
<td>10</td>
<td>-</td>
<td>9</td>
<td>11</td>
<td>Very good</td>
</tr>
<tr>
<td>Tree lucerne</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>Good</td>
</tr>
<tr>
<td>Medicago sativa</td>
<td>-</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>Low</td>
</tr>
<tr>
<td>Desmodium spp.</td>
<td>-</td>
<td>3</td>
<td>8</td>
<td>8</td>
<td>-</td>
<td>4</td>
<td>Low</td>
</tr>
<tr>
<td>No. of beneficiaries</td>
<td>26</td>
<td>56</td>
<td>28</td>
<td>35</td>
<td>65</td>
<td>398</td>
<td></td>
</tr>
</tbody>
</table>

Source: Kembata Tembaro zone, Kedida Gamela Office of Agriculture, 2011;
* root splits in thousands, **cuttings/root splits in thousands

Private and research sector involvement in forage seed distribution

Private sector organizations found in the region are involved mainly in collection and dissemination of forage seeds or vegetative materials. They obtain forage seeds from farmers, private producers and other informal suppliers for dissemination. None of the private seed collecting and distributing agencies in the region have seed quality testing and seed storage, purchasing seeds with observed physical purity and uniformity and storing them in a cool house for a maximum of two years. Most of the forage seeds obtained from farmers are from forages with large pods like cowpea, pigeon pea, Lablab purpureus, Sesbania sesban, and from those forage seeds which could be obtained with minimum labour inputs like Chloris gayana and Panicum maximum. They obtain fodder beet and alfalfa seeds from other partners (research organizations and non-governmental organizations). The Agro-seed Agricultural Inputs Supply Private
Agency (Soddo) and the Zegba Agricultural Seed Inputs Supply Enterprise (Hawassa) are among the private agencies actively involved in forage seed collection and distribution. All the private bodies identified a fluctuating trend in forage seed supply and marketing and concluded that market fluctuation is the dominating determinant factor for forage seed production. Supply of seeds of some species is limited by season, particularly for small-podded seeds, like alfalfa and Desmodium.

Forage seed producers are not well organized to collect, store and test forage seeds. Individual farmers produce almost all forage seeds on a contractual basis and cooperative supported farmers and disseminated using informal seed dissemination pathways. Alemayheu & Alan (1998) described the contractual seed system with service cooperatives, producer cooperatives and individual farmers for FLDP. However, once such projects end, the contractual system ceases and forage seed production stops.

Forage seeds are produced and disseminated mainly by the informal sector in the Region. ILCA (1994) reported that much of the forage seed production in Ethiopia is from the informal or traditional seed sector where farmers do their own selection and seed production to meet their own needs and may also sell or exchange excess seeds within the local community. When seeds of poor viability are distributed, the consequence is low germination and poor establishment. This affects the adoption rate of forage and pasture plants.

Although there have been studies in Ethiopia on improved forages and forage seed production, they are not well coordinated and do not cover all the agro-ecological zones and farming system. ILCA (1994) also reported that pasture seed production in Sub-Saharan Africa is still poorly developed, often because of poor selection of species for environment or niche in the farming system.

**Constraints and Opportunities**

There is an increased demand for improved forage seeds following increased use of high grade and crossbred animals and market demand for livestock products and a range of forages have been identified for the diverse agro-ecologies and farming systems of the region. Despite the increased awareness of the importance of integrating forage crops into the existing farming system to solve livestock production problems in the region, there is a problem of obtaining seed and vegetative materials to establish forage production. Seeds obtained from uncertified sources are poor in purity and viability. Farmers do not use fertilizer and associated management packages for forages, thus, it results in low production. Land is also a barrier to the adoption of improved forages in the
central south region, where population density is high. The extension system is also generally poor and its contribution for promotion of forages is reported to be low.

Reports indicated that there is no market for the forage seeds produced reflecting poor supplier to market linkages. This has resulted in limited private sector involvement in forage seed production and marketing. Although cooperatives were formed to produce forage seeds under some projects, seed production ceased due to lack of budget, capacity and facilities at the end of the project and new projects rarely built on efforts in previous projects. There has been limited or no emphasis on forage seed production by the Ethiopian Seed Agency (ESA) that has affected the sustainability of the seed supply. The intervention of NGOs such as Action for Development and VOCA, projects such as IPMS, and Cooperatives and Unions, involved in livestock and forage production provide an opportunity to strengthen and improve the informal seed system as well as raise awareness and strengthen the capacity of smallholder farmers in forage and forage seed production.

Conclusions and Recommendations

Preliminary on-station research results and on-farm feedback from community-based forage studies indicated that the region has great potential to produce forage and forage seed. There is high demand for perennial grasses like Napier and ‘Desho’. Cuttings multiply these grasses or root splits and are easily established on soil and water conservation barriers, farm boundaries, fences and backyards. They are also known for their high biomass yield. Currently, these grasses are expanding at a fast rate in the watersheds of the region and efforts are being made to incorporate them in watershed management programmes. The farmers with better adoption in semi-arid and drought prone areas had better accept legumes like Sesbania and pigeon pea.

Forage seed dissemination value chains should be strengthened to improve access to seeds. Poor quality seed is a barrier for promotion of forages, indicating the need for immediate development of seed quality testing and seed certification mechanisms.

Capacity building and strengthening knowledge and skills through exchange of experiences and information in community-based forage and forage seed production are important to support linkages among all stakeholders. Research is also needed on improved management for seed set, especially on locally available and promising forage species (‘Desho’ grass).

Market information and marketing efficiency is poor for forage seeds in the region. Seed enterprises and seed marketing groups must establish their own
arrangement with buyers and improve communication to stimulate sales. Development of promotional material, advocacy and credit system arrangements are important components of successful marketing.

Such collaborative and concerted efforts in research and extension along with supportive national and regional government policies must go hand in hand to increase forage seed production quality and quantity for the farmers of our region.

References

Forage Seed Production in Eastern Ethiopia

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Introduction

Eastern Africa is recognized as the centre of origin and distribution of 8 to 10 of the most economically important tropical and sub-tropical pasture species contributing 20 - 25% of the total sown pasture species (Hartley and Williams, 1956). Feed shortage and poor quality of available feeds are the major constraints to increased livestock productivity in sub-Saharan Africa (Alemayehu, 2004).

The establishment and utilization of improved pasture can serve to improve quality feed supply to livestock. However, sowing a new pasture or improving an existing natural pasture requires a reliable source of seed or vegetative material of recommended forage species that are productive and adaptive for the area (ILCA, 1994).

This paper addresses accomplishments of the seed multiplication activities of the Haromaya University Rare, Fedis, Fafen and Kebribey multiplication sites.

Achievements

Types of forage species established

Haromaya and Fedis sites: These sites were established to simulate the highland and midland agro-ecological zone of the eastern Harerghe, respectively. Some of the established materials and forage species that successfully produced sufficient seeds at Haromaya site were alfalfa (*Medicago sativa*), oat (*Avena sativa*), vetch (*Vicia spp*), *Panicum spp. (P. coloratum and P. maximum)*, *Phalaris spp.*, *Chloris gayana*, *Cenchrus ciliaris*, and *Beta vulgaris* (fodder beet). At Fedis research site three species namely Sudan grass (*Sorgum sudanense*), *Lablab purpurous* and *Melilotus alba* were established successfully (Table 1). Of the three Sudan grass and *Lablab purpurous* were successfully established and produced seed.
Fafen and Kebribeyah Sites: These sites are found in Somali Regional State, Ethiopia. They are selected to represent settings of the agro-pastoral production system. Both sites are accessible for irrigation water and all established forage species were supplemented with irrigation. The forage species established at Fafen were Panicum spp. (*P. coloratum* and *P. maximum*), *Melilotus alba*, Sudan grass, different accessions of *Lablab spp.* (*Acc#11640, Acc #1160 and Acc #147*), *Cenchrus ciliaris*, *Chloris gayana* and *Macrotyloma axillare* (Table 2). At Kebribeyah site, species like *Pigeon pea*, Sudan grass, *Lablab spp* of the three above noted accessions and *Cenchrus ciliaris* were established with success.

**Table 1. Seed production at Haromaya (2008) and Fedis (2010) research sites**

<table>
<thead>
<tr>
<th>Type of seed</th>
<th>Sources of seeds</th>
<th>Sites</th>
<th>Land size (ha)</th>
<th>Quantity produced (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>Genesis Farm</td>
<td>Haromaya</td>
<td>1.5</td>
<td>105</td>
</tr>
<tr>
<td>Oats</td>
<td>SRC*, HRC &amp; DRC</td>
<td>Haromaya</td>
<td>1</td>
<td>200</td>
</tr>
<tr>
<td>Vetch</td>
<td>HRC &amp; DRC</td>
<td>Haromaya</td>
<td>0.25</td>
<td>5</td>
</tr>
<tr>
<td><em>Panicum coloratum</em></td>
<td>WRC</td>
<td>Haromaya</td>
<td>0.5</td>
<td>65</td>
</tr>
<tr>
<td><em>Panicum maximum</em></td>
<td>WRC</td>
<td>Haromaya</td>
<td>0.5</td>
<td>100</td>
</tr>
<tr>
<td><em>Chloris gayana</em></td>
<td>WRC &amp; HBOA</td>
<td>Haromaya</td>
<td>1</td>
<td>150</td>
</tr>
<tr>
<td><em>Cenchrus ciliaris</em></td>
<td>WRC &amp; HBOA</td>
<td>Haromaya</td>
<td>0.25</td>
<td>15</td>
</tr>
<tr>
<td><em>Phalaris spp.</em></td>
<td>SRC</td>
<td>Haromaya</td>
<td>0.5</td>
<td>9.5</td>
</tr>
<tr>
<td><em>Beta vulgaris</em></td>
<td>DRC</td>
<td>Haromaya</td>
<td>0.5</td>
<td>3</td>
</tr>
<tr>
<td>Sudan grass</td>
<td>HBOA</td>
<td>Fedis</td>
<td>0.5</td>
<td>10</td>
</tr>
<tr>
<td><em>Melilotus alba</em></td>
<td>HRC &amp; DRC</td>
<td>Fedis</td>
<td>0.25</td>
<td>5</td>
</tr>
<tr>
<td><em>Lablab purpureus</em></td>
<td>WRC &amp; HBOA</td>
<td>Fedis</td>
<td>0.5</td>
<td>6</td>
</tr>
</tbody>
</table>

*SRC, HRC, DRC, WRC are Sinana, Holetta, Debrezeit, and Werer Research Centers respectively, HBOA – Hawassa Bureau of Agriculture

**Outreach Activities**

The university uses various knowledge and technology transfer strategies to disseminate the research outputs so as to transfer knowledge and technology to potential stakeholders. The university as one of the established institution on agriculture celebrate a farmers’ day every year to share the information at hand and disseminate research outputs. Similarly, this year farmers’ day at different research sites of the university was conducted. Of these Haromaya and Fedis research sites where the forage demonstration is found were pat of the visit. During the farmers’ day, some improved forage varieties like *Lablab spp and
sudan grass were found promising as potential alternative animal feed and suitable for forage development delivery system through intercropping

Table 2. Summary of seed production at Fafen (2008) and Kebribeyah (2010) research sites

<table>
<thead>
<tr>
<th>Type of seed</th>
<th>Sources of seeds</th>
<th>Sites Fafen</th>
<th>Kebri-beyah</th>
<th>Land size (ha)</th>
<th>Quantity produced (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panicum coloratum</td>
<td>WRC*</td>
<td>✓</td>
<td>0.25</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Panicum maximum</td>
<td>WRC</td>
<td>✓</td>
<td>0.25</td>
<td>11.5</td>
<td></td>
</tr>
<tr>
<td>Chloris gayana</td>
<td>WRC &amp; HBOA</td>
<td>✓</td>
<td>0.50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Cenchrus ciliaris</td>
<td>WRC &amp; HBOA</td>
<td>✓</td>
<td>0.25</td>
<td>15.5</td>
<td></td>
</tr>
<tr>
<td>Melilotus alba</td>
<td></td>
<td>✓</td>
<td>0.50</td>
<td>11.6</td>
<td></td>
</tr>
<tr>
<td>Macrotyloma axillare</td>
<td>WRC</td>
<td>✓</td>
<td>0.25</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Sudan grass</td>
<td>HBOA</td>
<td>✓ ✓</td>
<td>0.50</td>
<td>35</td>
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<tr>
<td>Lablab Acc#11640</td>
<td>WRC &amp; HBOA</td>
<td>✓ ✓</td>
<td>0.50</td>
<td>66.5</td>
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<tr>
<td>Lablab Acc #1160</td>
<td>WRC &amp; HBOA</td>
<td>✓ ✓</td>
<td>0.25</td>
<td>14</td>
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<td>Lablab Acc #147</td>
<td>WRC &amp; HBOA</td>
<td>✓ ✓</td>
<td>0.25</td>
<td>18.5</td>
<td></td>
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<tr>
<td>Cenchrus ciliaris</td>
<td>WRC &amp; HBOA</td>
<td>✓ ✓</td>
<td>0.25</td>
<td>10</td>
<td></td>
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<tr>
<td>Pigeon pea</td>
<td>HBOA</td>
<td>✓ ✓</td>
<td>0.25</td>
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<td></td>
</tr>
</tbody>
</table>

*WRC- Werer Research Center, HBOA – Hawassa Bureau of Agriculture

Challenges

- Conceptual problems: forage development in general and seed production in particular is not considered as one of potential contributor to food security. Therefore, policy makers and planners hesitate to allocate money on forage development. Moreover, development agents and development practitioners give more attention to crop development than forage production;
- Limited skilled work force: both short and long-term training for forage production is not sufficient. As the result there is a serious shortage of skilled man power in the area;
- Insufficient forage seed production or availability and unaffordable seed prices for the users is another problem that discourages investment in the area of forage and/or forage seed production;
- Inadequate knowledge of the users about forage seed production and lack of proper extension services;
- Un-conducive geophysical and environmental factors, for instance frost is a major challenge in highland areas of the country; and
• Limited attention given by research establishments including universities to allocate proper budget and conduct research in the area.

Opportunities

• Low quality and quantity of the existing pasture, that necessitates strong support by high yielder and quality improve forages is an opportunity for one to involve in forage seed production. Like other seed business, forage seed production can also be considered as a potential income sources;
• Forage seed production can be a potential income sources for smallholder farmers and can be a source of income diversification; and
• The need for more forage seed production may create an opportunity for more practical attachment of university students and may create job opportunity for graduates.

References

Promotion of Forage Seed Production through Farmer-based Management around Hawassa

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Introduction

Although there are a number of promising forage species in terms of local adaptation and productivity, the dissemination of improved forage crops is extremely low due to various factors including problem of seed supply. The shortage of seed supply places a serious constraint on various national efforts to tap the potential of improved forage crops for increasing livestock productivity (Abate, 1998; Alemayehu Mengistu, 2004; Solomon Mengistu, 2008).

For the last several years, governmental and non-governmental organizations (NGOs) were repeatedly supplying forage seeds to farmers. However, the approach could not be sustainable. The forage seed supply and demand is constrained by the very high and unaffordable price of the desired forage seeds to local farmers, the low level of seed supply and its availability at the place and time required (Abule et al., 2009). On the other hand importing forage seeds is very expensive and not sustainable to meet the increasing seed requirements of farmers (Abraha, 1998). On the other hand farmers’ participatory based forage seed production is one of the options to establish a system of forage seed production in the community to improve forage seed supply systems in a sustainable way. This study was therefore aimed at promoting on-farm seed production of improved grass and forage legume varieties through farmer-based management at community level.

Material and Methods

The study area

The study was conducted at Hawassa Zuria, Shebedino and Inseno woredas in Southern Nations, Nationalities and Peoples Regional State (SNNPRS), Ethiopia in 2005 and 2006. All the woredas characterized by Weina Dega agro-ecological zone (Mid-altitude) and all the woredas received bimodal rainfall (have two rainy seasons) (NMA, 2010). The small rainy season (Belg) extends from middle
March to April while the main rainy season (*Meher*) extends from June to early October and the month of July and August receive the highest rainfall. However, there is a marked year to year fluctuation in the pattern of rainfall distribution.

**Selection of participating farmers and capacity building**

Four willing and potential farmers were selected from each woreda. The selection criteria were farmer’s interest, availability of land, accessibility and innovativeness of the farmers in the community. Training was given to the participant farmers and woreda development agents to acquaint them with proper management of forage seed production including seeding rate, time and method of seeding and the optimum stage of at which the seed is adequately mature to be harvested. Establishment requirements and post-harvest management under local situations are important considerations.

**Experimental design and treatments**

Two grass species (*Panicum coloratum* and *Chloris gayana*) and one-legume specie (*Medicago sativa*) were established on-farm on four farmer’s fields at each weredas in 2005 and 2006 in a randomized complete block design with four replications. The treatments were replicated on every farmer’s field. Each treatment was planted in rows on a plot size of 10 m *10m (100 m²)* and spacing between rows were 30cm. The seed rate was 15 kg/ha for the grasses and 10 kg/ha for the legume and the experimental plots were uniformly fertilized with 100 kg/ha DAP at planting. The upper portion of the grasses species (*Panicum coloratum* and *Chloris gayana*), along with the inflorescence is mowed at the right stage of seed development and heaped immediately after harvest and left under a shed to assist the final maturation of the caryopsis. Thereafter, the material is gently beaten to separate the seed from the sheaves, cleaned and weighted to determine seed yield while *Medicago sativa* was harvested by using hand-picking of the matured pod (Solomon, 2008). Seed sample from all location were collected and tested in Hawassa research center laboratory for their germination percentage.

**Farmer’s participation and evaluation of the forage seed**

Participatory approach was used in the process of forage seed production. Farmers were involved in all stage of activities from site selection, land preparation, planting, managing the trial and harvesting to evaluation. Farmers field day was organized and cross-field visit made between trial farmers and others in order to increase awareness on forage seed production in the community.
Results and Discussion

Seed yield and quality
Forage seed productivity was different among participant farmers and over locations. Yield variation was due to field management of the farmers, soil fertility conditions (usually farmers select land which is low in soil fertility that is the land not used for crop production), weeding, fencing (protection of the field from free grazing) and time of seed collection. Despite that the productivity is encouraging in all the woredas (Table 1).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Seed yield (kg/ha/year)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005</td>
<td>2006</td>
<td>Mean</td>
</tr>
<tr>
<td>Chloris gayana</td>
<td>183.3a</td>
<td>175.7a</td>
<td>179.5a</td>
</tr>
<tr>
<td>Panicum coloratum</td>
<td>205.8a</td>
<td>181.3a</td>
<td>193.5a</td>
</tr>
<tr>
<td>Medicago sativa</td>
<td>49.4b</td>
<td>59.1b</td>
<td>54.3b</td>
</tr>
<tr>
<td>Mean</td>
<td>146.2</td>
<td>138.7</td>
<td>142.4</td>
</tr>
</tbody>
</table>

P - level   0.001 0.008 0.0001
Location - - 0.58
Location*year - - 0.41

In all the tested locations seeds of forage crops were harvested only once annually. Among the tested forage crops, Panicum coloratum produced the highest seed yield followed by Chloris gayana. There was no difference (P>0.05) among the different treatments in the locations and years in seed yield of the forage crops. The findings were in the ranges of yields reported by Solomon (2008) where mean seed yield ranges from 45 - 400kg/ha, 65-650kg/ha and 100-300 kg/ha for the Panicum coloratum, Chloris gayana and Medicago sativa respectively. However, the seed yield of the Medicago sativa is contrary to those reported by Solomon (2008) where the seed yield of the Medicago sativa was below the range, this might be due to the poor farmers field management and lack of bees (honey bees) for pollination in the study area.

Seed quality was assessed in terms of germination percentage with simple bloating paper testing at room temperature. The values recorded for the three species were below the normal recommended level of about 85%, but this might be due partly to the test procedures followed. The highest germination percentage found was for Medicago sativa (72%) followed by Chloris gayana (65%) and Panicum coloratum (58%).
Farmers’ evaluation
Field day was organized and cross field visits were made among participatory farmers. Farmers, key informants, development agents and woreda agricultural expertise were involved in the field day. Participating farmers have realized that technology adoption is more successful when farmers them self participate in the process. Farmers were also appreciating the possibilities and appropriateness of forage seed production under farmers’ fields and management in the community. The farmers at Hawassa Zuria, Shebedino and Inseno used almost the same selection criteria’s of forage species including seed production, vegetative growth, herbage yield, palatability, performance under low management, fast growing, easily to harvest and uniform maturity of seeds (Table 2).

Table 2. Farmer’s criteria for selection of forage crops (According to farmers ranking 5 was the highest and 1 the lowest)

<table>
<thead>
<tr>
<th>Selection criteria</th>
<th>Panicum coloratum</th>
<th>Chloris gayana</th>
<th>Medicago sativa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetative growth</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Herbage yield</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Fast growing</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Easily to harvest</td>
<td>4</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Palatability</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Uniformly mature</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>High seed yield</td>
<td>5</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Fast growth</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

Farmers evaluated the performance of forage seed production and voted for Chloris gayana, Panicum coloratum and Medicago sativa respectively. As it performed well and give reasonable yield. The overall sum of criteria showed that Chloris gayana, Panicum coloratum and Medicago sativa were the best candidates for seed production at Shebedino, Hawassa Zuria and Inseno areas respectively. In this study it was realized that farmers are very well acquainted with the different management techniques of forage seed production. They are also expressed their willingness to produce forage seeds but they also expressed their fear that access to forage seed marketing could be a problem. According to the farmers, forage seed production should be considered as a means of source of income. It was also observed that farmers are actively observed when the technologies are very appropriate and identified in participation with farmers.
Conclusions and Recommendation

Though forage seed production especially for perennial crops is very difficult, it was found that *Chloris gayana*, *Panicum coloratum* and *Medicago sativa*, produced a reasonable high amount of forage seed in all the woredas tested under farmers management conditions. This suggests that perennial forage seed production possibilities in collaboration with smallholder farmers under contractual agreement or out-growers’ scheme. Awareness was created on forage seed production in the community level and farmers have the capacity to produce this scarce forage seed in the community level. Therefore; scale-up of forage seed production in the community level with participatory approach, through establishment of a seed producer cooperatives, providing technical support and creating market linkage is important intervention to solve forage seed shortage to make sustain livestock production and productivity in the Hawassa zurea, Shebedino and Inseno woredas in Southern Nations, Nationalities and Peoples Regional State, Ethiopia.

References

An Overview of Forage Seed Quality in Ethiopia

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Introduction

The availability, access to, and use of quality seed of adaptable forage crops are important in increasing forage production and productivity. Quality in seeds embraces all the physical, biological, pathological, and genetic characteristics, which contribute to the final yield of a forage crops. Seed is a living biological product, which requires special attention and care to ensure its all quality attributes. High quality seed is a major factor in obtaining a good crop stand and rapid plant development even under adverse conditions although other factors such as rainfall, agronomic practices, soil fertility, and pest control are also crucial. The quality of seeds alone is known to account for an increase in productivity of at least 10-15% depending upon the species and it can be further raised up to 45% with efficient management of the other inputs. Seed production should be strictly monitored throughout the entire crop growth period, from planting through to harvesting, drying, threshing, cleaning, packaging, storage and marketing. Hence, Seed producers should understand the principles and procedures for growing a forage crop for seed, and ensure that all operations are carried out at the right time and at the right place. Therefore, this paper attempts to briefly review the current status and gaps of forage seed quality in Ethiopia.

Seed quality attributes

Seed is alive, and it can change over time under varying conditions. It can also vary from year to year as do planting conditions. Forage seed quality is critical in the establishment of a uniform forage plant stand, the first step in producing a successful crop, but good planting conditions are also critical since high quality seed can fail under too much stress. So seed quality is a multiple concept comprising several components which may be divided in four major groups of genetic, physiological, physical and pathological qualities (Huda, 2001).

Genetic quality

The genetic quality is determined by the genetic information contained in the seed. The important factors are the inherent genetic information contained in the seed which provides the potential for higher yield, better seed quality, and
greater tolerance to biotic and abiotic stresses; and varietal identity specifically the transfer of seed of desired variety from the breeder to the farmer through successive generations of seed multiplications. A seed with poor genetic composition will not grow well in the field. Quality seed is expected to have superior inheritable quality so as to produce the expected biomass and seed yields. When forage crops are grown under different soil and fertility conditions, climatic conditions, photoperiods and elevation for several consecutive generations, the developmental variation may arise some times as differential growth response. To minimize the opportunity for such shifts to occur in forage species it is advisable to grow them in their areas of adaptation and growing seasons. Mechanical mixtures are the most important source of variety deterioration during seed production. It may often take place at the time of sowing, if more than one variety is sown with same seed drill; through volunteer plants of the same crop in the seed field; or through different varieties grown in adjacent fields. Often the seed produce of all the varieties are kept on same threshing floor, resulting in considerable varietal mixture. To avoid this sort mechanical contamination it would be necessary to rogue the seed fields, and practice the utmost care during the seed production, harvesting, threshing and further handling. In sexually propagated crops, natural crossing is another most important source of varietal deterioration due to introgression to genes from unrelated stocks which can only be solved by prevention.

**Physiological quality**

It refers to aspects of performance of the seed. It is the viability, germination and vigor of seed, which determines the potential germination and subsequent seedling emergence and crop establishment in the field. Viability is a potential to germinate. A nonviable seed will not germinate under any conditions. Viable and nonviable seeds may look exactly the same. Germination is the emergence from the seed and development of those essential structures that under favorable conditions produce a normal plant. Requirements for initiation of germination include: a favorable moisture level in the seed; a favorable temperature in the environment around the seed; and a favorable oxygen supply to the seed. Some seeds may require specific light. Also, the seed’s dormancy must be broken for germination to proceed. At the field level, seed vigor means the ability to germinate, to emerge and to produce healthy seedlings rapidly, uniformly, under a wide range of environmental conditions, and to maintain this ability for a long period. Many factors, such as maturity level at harvest, age of the seed, mechanical injuries, disease infection, and storage environment, can influence seed vigor. Genetic factors also influence vigor. Seeds low in vigor generally produces weak seedlings that are susceptible to environmental stresses. Seeds high in vigor generally provide for early and uniform stands that give a competitive advantage for seedlings against environmental stresses. Seed lots that have low germination are also less vigorous due to seed deterioration. As
seeds deteriorate, loss of vigor precedes loss of viability, so seeds with low germination usually will be less vigorous. Hence, in seed lots with poor germination, those seeds that do germinate often produce weaker seedlings with reduced yield potential. However, some species have inherently low germination potential and cannot be assumed to have poor vigor due to low germination. Germination and seed size often are good indicators of seed vigor.

**Physical quality**
Physical qualities of the seed are characterized by minimum of damaged seed, minimal weed seed, or inert matter, minimum of diseased seed and near uniform seed size. Damaged (broken, cracked or shriveled) seed may not germinate and is more likely to be attacked by insects or micro-organisms. Good quality seed should be free of weed seeds (particularly noxious types), chaff, stones, and seeds of other crops. Discolored or stained seed are symptoms of seed that may carry micro-organisms that already have attacked the seed when it starts to grow. The plant may live and spread the disease to other plants. Mature, medium and large-size seed will generally have higher germination and vigor than immature and small sized seed. Generally, in the conditioning of seed lot, broken, shriveled, weed seeds, chaff, stones, seed of other crops, discolored seeds, undersized seeds and light seeds are normally eliminated.

**Pathological quality**
Seed health is an important attribute of quality, and seed used for planting should be free from pests such as fungi, bacteria, viruses, nematodes, insects, etc. Seed infection may lead to low germination, reduced field establishment, severe yield loss, or a total crop failure. Seed productions in disease free areas, or under effective disease control and field inspection schemes, are very important for obtaining healthy seed. Thus, understanding the disease epidemiology, its transmission rate and economic threshold, combined with seed health testing, could help define the need for seed treatment. Chemical seed treatment is one of the most efficient and economical plant protection practices and it can be used to control both external and internal seed infections. It also protects young seedlings or adult plants from attack by seed, soil or air-borne pests. It disinfects seed of pathogens, checks the spread of harmful organisms, promotes seedling establishment, improves seed quality and minimizes yield losses. Seed treatment is preferable over other conventional methods because it is easy to apply, and better targeted against the organism.
Stages in Quality Seed Production

Pre-planting stage
Apart from agro-ecological and climatic adaptation, the area selected for seed production should be free from natural hazards like floods, drought, frost, salinity, diseases and insect pests, etc., to prevent any damage on forage seeds quality. The right previous cropping history is necessary to avoid genetic, mechanical and pathological contamination in seed production, whereas crop rotation is mainly practiced to maintain soil fertility and control soil and/or seed-borne diseases. The land selected for forage seed production should be free from varieties of the same crop species for at least one or two years prior to planting unless the previous crop is of the same variety. Moreover, the seed production field should be properly isolated from other cultivars of the same species to avoid mechanical admixture and cross pollination. A larger isolation distance is required for cross-pollinated forage crops than self-pollinated crops. Although the field size, topography of the site, wind speed and direction, insect type and population, and cropping patterns influence the risks of contamination, standard isolation distances are usually recommended.

Forage crop must be planted at its recommended time on well prepared and weed free fields, otherwise growth and development may be affected, thus reducing seed quality. In general, late planting is not recommended because it can lead to substantial reductions in seed yield and quality. Early planting on the other hand, is beneficial but may increase risks of early dry spells, frost damage, and weed infestation. The recommended seed rate should be used when a crop is sown at normal time to achieve the right plant population for adequate competition with weeds and for better seed yield and quality. Planting at a higher than the recommended rate, is not encouraged because of its negative impact on seed quality, particularly on seed size and weight. Instead of using higher rates, farmers must pay close attention to all recommended seed production practices. In seed production, planting in rows has advantage over broadcasting, as it requires less seed, facilitates, mechanical weed control, pesticide spray, access for rouging and field inspection, and produces better yield and quality.

Fertilizer application to seed crops should be based on local recommendations. High nitrogen levels may promote vegetative growth, cause delayed maturity, predispose the crop to foliar diseases, lead to severe lodging and reduced yield and seed quality. Phosphorus is essential for enhancing seed maturity, and potassium for enhancing seed development. Improved forage crops are reasonably responsive to fertilizers and the seed yield potential cannot be fully realized without inorganic fertilizers application. In view of the general deficiency of nitrogen and phosphorus in most soils, a balanced use of these
nutrients is essential. Apart from the type of fertilizer, the time and method of application of the fertilizer is very important. Phosphorus and potassium are relatively stable in the soil and can be applied at the time of planting. However, nitrogen fertilizers are volatile, a minimum of two split applications is necessary, i.e., one at planting and the second during crop growth.

**Post-planting stage**
In forage seed production, contamination of the seed crop with other crop or weed seeds of similar physical characteristics must be reduced to the barest minimum because cleaning alone will not sufficiently remove such contaminants. A well designed integrated weed control package combining crop rotation, inter-row cultivation and hand pulling, coupled with herbicide application, is commonly used. Forage seed fields should be rouged before undesirable plants cause genetic or physical contamination, because during crop growth stages the rogues can be identified visually. Rouging can be performed at various stages of crop growth, but the most effective stages are flowering, post-flowering or maturity, when it is easier to see important morphological characteristics that will help differentiate between the variety and the rogues. Freedom from pathogens, especially seed-borne diseases, is one of the most important seed quality attributes and standards. Isolation, field inspection, rouging of infected plants and application of chemical treatment are crucial for the production of healthy seed.

Each type of plant has an optimal time for the seeds to be harvested, but factors such as climate, weather, disease, insects, birds, or predatory mammals may require that the seeds are harvested before that time. When a large number of maturing seeds are present, any color changes in individual seeds are reflected in the overall appearance of the forage crops. This method is more useful when crops are reasonably well synchronized. Maturation may be uneven within the pod, cob, or panicle, or uneven on the plant, and uneven within the stand of plants. It is more difficult to determine the optimum harvest dates for indeterminate plants because of the longer flowering period. For that reason, the pods of many plants are harvested individually. Seed quality depends on position of seeds in the plant, maturity, seed size, vigor etc. (Khatun et al., 2008). Early harvested seeds will be immature and less developed and as such perform poorly in store compared to seed harvested at the right physiological maturity (Singh and Lachanna, 1995). Physiological maturity is the stage at which translocation of food materials to the seed stops and represents the highest quality level but moisture is too high for storage. But harvest maturity occurs 7-10 days following physiological maturity and is an important process where moisture is lost from the plant and is safe for storage. Grasses and legume seeds reach physiological maturity between 35 and 45% and 45 and 50% moisture content, respectively. Attainment of physiological maturity is a genotypic character which is
influenced by environmental factors (Mahesha et al., 2001a). Low seed moisture content, resulting from delayed harvesting, increases shattering losses and excessive seed injuries. The moisture content of the seed can be used as an indicator of when the crop is ready for harvesting. The crop characteristics or electric moisture meters can be used to decide the time to harvest.

Field inspection is a systematic procedure to verify the levels of contamination with off-types, other crops, seed-borne diseases, and noxious weeds in forage seed multiplication fields. During inspection, by comparing the results against prescribed set of standards, the seed fields can be approved to be harvested for use as seed or discarded. Continuous and rigorous supervision is needed in quality seed production. The first thing is to verify the suitability of the site and field for seed production. The second is to check on plant density and need for weed control during seedling emergence and establishment. The third is to inspect the field to certify or discard the seed crop at full maturity. Regular field visits are necessary for proper forage crop management and monitoring. Field inspection is one of the practices that differentiate quality seed production from biomass production. It is a measure to ensure that the seed produced will meet the seed quality standards. It assesses the potential risks of contamination and remedial actions required. Failing to inspect seed production fields may adversely affect all quality attributes and standards of the harvested seed.

**Post-harvesting stage**

After harvest, seeds must be threshed, cleaned, and dried ready for storage. Cleaning includes the removal of inert matter; seed of weeds, other crops, other varieties and seeds of the same variety which are shriveled, damaged, deteriorated or diseased, to improve and upgrade seed quality. These must be removed through threshing and cleaning process to obtain good quality seeds of the required cultivar. Traditionally, winnowing follows threshing, to remove chaff, straw and other light materials from the seed. Generally cleaning is the process of physically removing undesirable elements in a given seed lot, leaving only the pure seed component.

Most forage seed is stored for some period of time. During this time, seed may deteriorate considerably. Deterioration means the loss of some key physiological functions, with ultimate leads to loss of essential seed quality attributes like viability, germination and vigor. The rate of deterioration varies among forage crops. Starchy seeds, such as grasses generally have a slower rate of deterioration compared to oily and high protein seeds such as legumes, when all other factors such as temperature, humidity, and moisture content of the seed are the same. Differences also exist in deterioration rates among varieties of the same forage species. Seed deterioration cannot be put off indefinitely. Germination remains unchanged for a period of time during storage and then
declines rapidly. As seeds age, both germination and vigor decline, slowly at first and then more rapidly at the end of the seed’s useful life is reached. Seed vigor declines faster than germination. Keeping the store clean, cool and dry is the best forage seed management practice because this reduces physiological processes, fungal and insect activities.

Storability of forage seeds is mainly a genetical character which might be influenced by pre-storage condition of seed, seed maturation and environmental factors during pre and post-harvest stages (Mahesha et al., 2001b). Newly produced forage seed must be stored in new bags because old bags can be a source of contaminants and insect infestation. Most forage crops, with few exceptions, have a medium to long-term storage period with minimum loss of viability. Generally, grasses store better than legumes, and legumes store better than oilseed crops (seeds with high level of oils). During storage, seed quality can remain at the initial level or decline to a level that may make the seed unacceptable for planting purpose which is related to many determinants: environments conditions during seed production, pests, diseases, seed oil content, seed moisture content, mechanical damages of seed in processing, storage longevity, package, pesticides, air temperature, relative air humidity in storage, and biochemical injury of seed tissue (Guberac et al., 2003; Heatherly and Elmore, 2004).

Forage crop seeds are orthodox type i.e. they are not sensitive to low moisture and temperature hence can be dried to very low moisture content and stored at very low temperatures. The moisture content of the seed is the most critical factor affecting the rate of deterioration. According to Yadav et al., (2005), harvesting at high moisture content increases the changes of mycofloral infection on seed while harvesting at low moisture content increases mechanical damage to seed. The level of seed moisture content is one of the key factors that determine when farmers can start harvesting the crop. After harvest the seed can be further dried by spreading the seed on drying floors through exposure to the sun. Particular attention is given to seed moisture content after harvest to ensure that seed can be handled and stored and processed so that it retains high germination. Seed is hygroscopic; it will absorb moisture from the surrounding air or release moisture into the air depending on the moisture content of the seed, temperature and relative humidity of the air. After the initial drying and during storage the seed can absorb moisture from the air or releases moisture to the air until it comes into equilibrium with the relative humidity of the air. So seed drying is important to prolong shelf life and protect seeds from easy attack by insects and pests during storage. The optimum moisture percentage of forage seed depends on the type of species and the temperature. Some legumes seed can be easily damaged if the seed is too dry. The lower the seed moisture percentage is, the slower the rate of seed respiration. A slower rate of seed respiration
results in a slower rate of deterioration. Therefore, proper drying of the seed is critical for minimizing deterioration during storage. So, most seeds are dried to a safe moisture level, between 10 and 12%, before processing and storage.

Temperature and relative humidity of the storage environment are the two most critical factors to pay attention when longer seed storing period is considered without losing its viability. The lower the temperature and relative humidity, the longer the seeds can be safely stored. In general, the seed crop should be dried only at a recommended temperature level. Too high temperature will damage seeds by reducing their vigor or can result in death and too low temperature may also cause heating and molding which can also result in the death of seeds. The general effect of temperature on longevity is that longevity increases as temperature decreases. The relative humidity and temperature of the store are controlled by mechanical means. This is usually used for processed, packaged and high value seed because of the high cost of controlling the environment. Conditioned stores are required in humid tropical conditions if ambient temperatures exceed 30°C and relative humidity is 70% or more.

**Status and Gaps of Forage Seed Quality**

**Status of forage seed quality**

Though forage crops are introduced since more than 5 decades ago, its adoption by farmers is still not very well developed due to various factors. Seed availability is one of the major reasons. There are no private farmers producing forage seeds in the country. Very few private forage seed producers are currently starting the business. Some research institutes and others are trying to produce some forage seeds. But, these are also constrained with the expertise, facilities, finance and many more. Under these situations the status of forage seed quality both produced locally and imported from abroad has been given very little attention. However, seed growers are encouraged to consider and understand seed quality components to produce quality seed that can save time money during forage production

Physical impurity is common in many perennial forage grasses and legumes seed such as Rhodes, stylosanthes, alfalfa and others. This is due to the growers poorly identify forage seeds from other foreign materials, lack of availability of seed threshing and cleaning facilities, and presence of seeds of different weeds could also be problems in some cases. Most of the forage crops are recommended at species level so that genetic purity is less important, but for cross-pollinating forage crops such as alfalfa, and some browse trees like tagasaste and species which have many varieties like oats, the genetic purity is crucially important. There are a lot of interrelated forage seed production
problems which may result physical and genetic impurity at field and storage conditions. According to Getnet et al., (2012), some of the reasons for genetic impurity are the lack of skills and awareness on varietal differences and on management of pure seed production especially at smallholder farmers’ level; the lack of seed quality control system including official variety release, control of genetic purity at field level, seed certification; and absence of enough seed producing enterprises.

Physiological purity is another important seed quality parameter for successful establishment and production of forage and pasture crops. Almost all the research activities in seed quality conducted at the Ethiopian Institute of Agricultural Research (EIAR) and regional research centers are mainly on seed germination. Seed viability (germination) test is very important before planting of forage crops to get optimum plant population at field conditions. Seed production managements at different growth stage and post harvest handling, treatment and conditioning have a great effect on physiological quality (viability, germination and vigor) of forage seeds. Seeds of many forage species could be stored for longer period of time especially in the cooler highland areas like Holetta. A study on shelf life of some forage seeds are shown in Table 1. The result indicated that mean germination percentage of different forage seeds have a decreasing trend over the five testing years but the rate is very low for some of the species, indicating that they have longer storage life. It is also observed that seeds of some forage crops such as alfalfa and vetch can be stored more than ten years under cool room temperature conditions in the highland areas like Holetta.

<table>
<thead>
<tr>
<th>Forage species</th>
<th>Germination over years of storage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st year</td>
</tr>
<tr>
<td>Phalaris tuberosa</td>
<td>64</td>
</tr>
<tr>
<td>Lolium perenne</td>
<td>46</td>
</tr>
<tr>
<td>Festuca arundinacea</td>
<td>68</td>
</tr>
<tr>
<td>Chloris gayana</td>
<td>28</td>
</tr>
<tr>
<td>Panicum coloratum</td>
<td>61</td>
</tr>
<tr>
<td>Avena sativa</td>
<td>93</td>
</tr>
<tr>
<td>Medicago sativa</td>
<td>95</td>
</tr>
<tr>
<td>Vicia species</td>
<td>89</td>
</tr>
<tr>
<td>Mean</td>
<td>57</td>
</tr>
</tbody>
</table>

Table 1. Germination (%) of seeds of different forage crops at different storage durations under room temperature and humidity conditions at Holetta in the highlands of Ethiopia.
The other beneficial qualities of many forage seeds is low level of disease and storage pest problems like weevil. Despite that (germination) viability is poor for many species due to mainly management problems. Identification of the right seed harvesting stage for each forage species is constrained by indeterminate growth, lack of uniformity in maturity, and lack of experience. In addition environmental fluctuations are also very important causes, in some seasons crops are growing very well and reach to optimum harvesting stage on the right period for harvesting, while some seasons are either very wet or dry which occasionally followed with frost, these situations create difficulties when to harvest and also affect the seed quality remarkably. Research results at Holetta showed that, harvesting stages after full flowering have a great effect on quality (germination) of some perennial forage species (Table 2). Lack of appropriate skills for post harvest handling viz, drying, threshing, cleaning, winnowing, packing, storing, transporting and marketing have also an effect on the quality of forage seeds. Selection of the right niches also to be considered to produce viable forage seeds. Some forage crops such as fodder beet (Beta vulgaris), alfalfa (Medicago sativa), etc., are site specific for production of viable seeds. Though fodder beet gives seed at Holetta, the seeds are not viable because the crop needs some chilling temperature at flowering and seed setting stages, but this crop gives viable seed at Meraro. Due to the presence of high frost and rain fall at flowering, seed setting and seed maturity stages, production of good quality seeds from late maturing forage crops is a great problem in the highland areas. After flowering stage, low soil moisture content and high temperature can also cause a critical problem on seed quality of late maturing forage crops in the lowland areas. Therefore, environmental stresses such as frost, extreme temperatures, soil moisture, soil acidity, and soil salinity should be considered before selection of sites and forage species for production of quality seeds.

Table 2. Effect of harvesting stage after full flowering on the germination percentage of grasses at Holetta

<table>
<thead>
<tr>
<th>Harvesting stage (Weeks after full flowering)</th>
<th>Phalaris</th>
<th>Rhodes</th>
<th>Panicum*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
<td>77</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>72</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td>82</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>45</td>
<td>88</td>
<td>33</td>
</tr>
<tr>
<td>5</td>
<td>51</td>
<td>80</td>
<td>23</td>
</tr>
<tr>
<td>6</td>
<td>63</td>
<td>78</td>
<td>24</td>
</tr>
</tbody>
</table>

*Germination % was on average doubled when storage is prolonged to 2 years.
Seed dormancy is most common in wild flora for survival purposes under unfavorable environmental conditions (Baskin and Baskin, 2004). Some forage species are dormant when harvested, and the dormancy period may last for a few weeks to several months. When seeds are dormant, they are still viable but will not germinate when placed in the proper germination environment. Some improved forage crops still carry genes for seed dormancy. Forage crops such as phalaris, rhodes, panicum, setaria, clovers and browse trees have got dormancy problem due to inherent (mechanical and physiological) dormancy, chemical dormancy, and enforced dormancy (Getnet et al., 2012). Most fabaceae seeds such as alfalfa (Medicago spp.), clovers (Trifolium spp.) and etc., have hard seed coat due to the thickness and biochemical composition of their testa, which limit the absorption of water. Thus, special seed pre-conditioning treatments must be used to break or overcome seed dormancy.

Three common scarification techniques are used to soften or break the seed coat. These are mechanical, chemical and heat scarification. Mechanical scarification is simple, cheap and safe and is recommended for the majority of forage legume seeds. Variations in hardseededness in annual clovers are affected by both genetic and environmental conditions during plant growth, seed development and maturation. Hardseededness varies within and between species. It is affected considerably by the pre- and post-harvest conditions. Small quantity of clover seeds can be scarified manually using sandpaper. Care should be taken not to damage the seed coat at the end furthest away from the embryo to avoid killing the seed. The seed coat may also be treated by immersing the seeds in concentrated sulphuric acid for 7-20 minutes (depending on the species and thickness of the seed coat) followed by washing and drying. However, this treatment can damage the seeds and different species have different degree of resistance. Generally this is an expensive and dangerous method and therefore considered unsuitable for seed scarification. Some seeds, especially those with waxy or oily seed coats, can be effectively scarified using boiling water. A good practical way of doing this is to soak the seeds in boiling water for a few seconds, followed by overnight drying. Table 3 indicates that germination potential of tagasaste seeds can be improved from 1.5 to 80.5% by treating the seeds with hot water.

According to Getnet et al., (2012), soaking the seed of tagasaste in boiling water for 9-11 minutes is used to decrease the hardness of seed coat, and thereby increase the germination percentage from 3% (untreated seed ) to more than 75% (Table 3). The plant growth regulator, ethrel was effective in dormancy breaking in some forage crops seeds (Globerson, 1978). Smoke is also an effective agent in breaking seed dormancy of many species (Minorsky, 2002).
Table 3. Effect of hot water treatment on the germination of tagasaste seeds

<table>
<thead>
<tr>
<th>Length of boiling water treatments (minutes)</th>
<th>% Germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>63.5</td>
</tr>
<tr>
<td>2</td>
<td>68.5</td>
</tr>
<tr>
<td>3</td>
<td>74.5</td>
</tr>
<tr>
<td>6</td>
<td>76.5</td>
</tr>
<tr>
<td>9</td>
<td>80.5</td>
</tr>
<tr>
<td>12</td>
<td>68.5</td>
</tr>
<tr>
<td>15</td>
<td>63.0</td>
</tr>
<tr>
<td>18</td>
<td>67.5</td>
</tr>
<tr>
<td>21</td>
<td>55.5</td>
</tr>
<tr>
<td>24</td>
<td>28.5</td>
</tr>
<tr>
<td>Control</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Gaps of Forage Seed Quality

Different forage species need suitable seed production sites when compared to forage (biomass) production sites. There is a great gap exists in the identification of suitable seed production sites for recommended forage crops which has a substantial contribution for good quality seed production. Forage seed production technologies such as harvesting management, seed cleaning, processing, and conditioning should be developed and extended to producers for production of quality seed. Government and private forage seed production, seed cleaning and processing centers are weak so it should be strengthen. There is no forage seed certification in the country and all stakeholders should support the establishment of seed certification system.

Seed quality is an important aspect for successful forage establishment, conservation and exchange of forage genetic materials. In Ethiopia forage seed quality research and its application in the various development activities are highly undermined and do not have much attention. Seed quality is not also virtually considered in the extension activities of forage crops. If things are continuing like this, its impact and consequences could be very risky. Different forage species are introduced from many countries by federal and regional research centers for improvement of the livestock sector of the country. Establishment of well structured effective and strong quarantine system is the
first and most important step in the production of quality seed in the country. However, for introduced germplasms, there are no strong laboratory quartine services and no well established quartine fields for assessments of forage seed quality in the country. Therefore, strengthen the proper quartine service of the country is very important to protect the ecology from various pests, diseases and weeds.

**Conclusions**

In the development of forage and pasture crops, the quality of the seeds used has a profound effect on the expected output. The demand for forage seed in Ethiopia is increasing in alarming rate from time to time but substantial gap exists in satisfying the demand of quality seed. Most forage seed supplied by different organizations lacks the standard quality attributes. This is mainly due to shortage of qualified personnel in seed technology, lack of adequate facilities for internal quality control and short term storage, lack of appropriate breeder seed maintenance storage facilities to keep the quality standard; and inadequate budge for breeder and pre-basic seed multiplication. Production of genetically pure and good quality seed is a cost demanding task that requires high technical skills and comparatively huge financial investment. During seed production, strict attention must be given to the maintenance of genetic purity and other quality parameters in order to fully exploit the genetic potential of the forage crops under production. This is usually expressed in terms of the yield produced, the quality of the forage and its subsequent use as a seed. If seeds are not desired quality the possibility of getting of weeds, diseases and pests is expected. This generally will result in reduction of the overall yield, affecting other fields and the overall environment at large. Forage seeds have some specific characteristics when compared to seeds of food and horticultural crops. Long shelf life, resistance to field and storage pests and diseases, are some of the beneficial qualities of most forage seeds. Generally, improving all seed quality attributes through proper management at per-and post-harvesting stages, are critically important for promotion of the livestock feed sector in the country.

**References**

Baskin, J.M., and Baskin, C.C. 2004. A classification system for seed dormancy. Seed science research 14, 1-16

Australia Journal of Agricultural Research 29, 43-49.
Potentials and Constraints of Forage Seed Production and Dissemination through Extension in Southern Region

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Introduction

The livestock population is estimated at 38.7 million cattle, 18 million sheep, 14.8 million goat, 5.7 million equines and 0.45 million camels in Ethiopia (CSA, 2005). Similarly, in the southern region of Ethiopia there is a total of 10,543,129 cattle, 4,935,092 sheep, 4,057,497 goats, 335,709 horses, 424,931 donkeys, 57,437 mules, 850,364 poultry, and 774,980 beehives (CSA, 2009). The lion’s share of the country livestock is found in the three major regional states, Oromia Regional State, Amhara Regional State, and Southern Nation Nationalities and People Regional State (SNNPRS), each accounting for 43%, 26% and 20% of the national livestock population, respectively (CSA, 2003). Despite the huge livestock resource of Ethiopia, the largest in Africa, the productivity of livestock is remarkably low.

Livestock production is an integral part of the subsistence crop-livestock systems of SNNPRS of Ethiopian. Livestock plays significant contribution not only as a source of draught power, manure and transport to support the crop sector but also serves as a source of cash, nutrition and asset for the rural communities. It is considered as a mobile bank that could be hired, shared, inherited and contracted by rural households. Although livestock’s contribution to facilitate the crop sector has been recognized all along, livestock productivity in Ethiopia is declining to a level that may affect sustainability of crop-livestock systems (Solomon, 1999; Romney et al., 2003; Tilahun and Kirkby, 2004). Numerous constraints are believed to be causes for the low animal productivity in the SNNPRS. Among other factors, feed shortage, both in terms of quantity and quality is a major constraint for the development of the livestock industry in the country. To partly curb problem of feed for livestock, enhancing improved forage production is a potential option. However, transfer of available forage technologies to the beneficiaries requires availability and supply of forage seeds. So far there is no organization or individual that has taken the mandate of forage crop seed production and dissemination in the SNNPRS or the country at large.
The Fourth Livestock Development Project of the Ministry of Agriculture developed some small scale forage seed production strategy on contract basis with farmers. This strategy, however, produced small amount of forage seeds from only legumes and browse tree species, and failed to meet the demand of the country. Hence, large quantity of forage seeds, especially grasses, was imported for various development works (Alemayehu, 1994). Therefore, the aim of this paper is to bring to the attention of the stakeholders about the potential, the constraints, and dissemination of forage seed production in the SNNPRS of Ethiopia.

**Feed Resources Management and Utilization**

The overriding constraint in the mixed crop livestock and pastoral production systems is the inadequate feed supply (Table 1) to support even moderate levels of production of livestock. The feed resources available are poor in quality, quantity and can’t meet the fed requirement of the livestock, which had impact on the productivity of the livestock (Table 2). According to different research works conducted in the SNNPRS, the available feed supply was estimated to cover about 60-70% of the total maintenance requirement of the livestock in the region (Yeshitila, 2008; Mergia, 2009). In almost all areas of the country livestock nutrition is characterized by highly seasonal fluctuation both in quantity and quality that lead to nutrient deficiencies including deficiencies of some minerals like phosphorus, copper and zinc. Shortage of grazing land, poor soil fertility and natural resource deterioration, and unreliable and markedly seasonal rainfall are the main and interrelated causes for deficient feed supply. Seasonal shortage of feed is severe in the lowlands as water availability is a critical problem in most of the pastoral areas. In the lowland pastoral areas, the sparse grazing and browsing natural vegetation on rangelands, which is already over-utilized, provides a week feed resource base to livestock. Agro-industrial by-products are not readily available at the farm level and their use is limited due to availability, high cost of the material and transportation cost.
Table 1. Total area used and amount of feed produced in 2005 and 2010 in the SNNPRS

<table>
<thead>
<tr>
<th>Activities</th>
<th>Unit</th>
<th>2005</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved forage development</td>
<td>Hectares</td>
<td>3580</td>
<td>5585</td>
</tr>
<tr>
<td>Grazing land closure &amp; improvement</td>
<td>Hectares</td>
<td>1606</td>
<td>3205.72</td>
</tr>
<tr>
<td>Crop residue collection for feed</td>
<td>Ton</td>
<td>150000</td>
<td>232550</td>
</tr>
<tr>
<td>Ammunition of crop residue</td>
<td>Ton</td>
<td>-</td>
<td>522.32</td>
</tr>
<tr>
<td>Hay production</td>
<td>Ton</td>
<td>5052</td>
<td>11500</td>
</tr>
</tbody>
</table>

*Source: Southern Ministry of Agriculture and Rural Development, 2010; SNNPRS = Southern Nations Nationalities Peoples Regional State*

Table 2. Percentage of livestock feed resource available in the SNNPRS

<table>
<thead>
<tr>
<th>Type of feed resource</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop residue (Treated or untreated)</td>
<td>35</td>
</tr>
<tr>
<td>Grazing</td>
<td>25</td>
</tr>
<tr>
<td>Crop aftermath</td>
<td>17</td>
</tr>
<tr>
<td>Perennial crop like enset, banana &amp; forages grown under perennial crops</td>
<td>12</td>
</tr>
<tr>
<td>Closure area / cut and carry system/</td>
<td>8</td>
</tr>
<tr>
<td>Improved forage</td>
<td>3</td>
</tr>
</tbody>
</table>

*Source: Southern Ministry of Agriculture and Rural Development, 2010; SNNPRS = Southern Nations Nationalities Peoples Regional State*

**Potential of Improved Forage Production**

Adapted under rain fed conditions of the region, the mixed crop-livestock farming system areas of the SNNPRS suffers from the reduction in the availability and quality of feed resource base, partly due to the expansion of crop cultivation as a result of the increasing human population. With increase in farming population, the number of livestock has increased, which further created an imbalance between feed demand and supply. Such factors placed enormous stress on the traditional land management practices. As a result, most palatable forage plants are becoming limited, because of the rangeland degradation and over grazing, that has lead to deterioration of the range ecology further aggravating the problem of feed supply for livestock.

The livelihood of agro-pastoralists as well as farmers in the mixed crop-livestock production system of the SNNPRS is highly dependent on livestock production. As it has already been noted livestock, production in the region is mainly
constrained by feed shortage. In order to alleviate the feed shortage problem in
the region, Hawassa Research Center has introduced and evaluated various
improved forage species, and recommended high yielding and well-adapted
forage species for the different agro-ecologies of the region (Table 3). Conse-
quently, adapted forage species from grasses *Pennisetum purpureum* and
*Chloris gayana*, from annual legumes *Lablab purpureus* and *Vigna ungu-
culata* and from perennial legumes *Desmodium intortium* and *Medicago sativa* were
accepted by the farmers as high yielding and well-adapted forage crops for the
Region.

Table 3. Major type of forage crops and development strategies in the Region

<table>
<thead>
<tr>
<th>Type of forage crop</th>
<th>Altitude (Agro-ecologies*)</th>
<th>Forage development strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
<td>Mid</td>
</tr>
<tr>
<td>Grasses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Rhodes</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Elephant</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Guatemala</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desho</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Legumes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desmodium</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cowpea</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Lablab</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Vetch</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Browse</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sesbania</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Trelucern</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

*Traditionally classified as Dega (highland), Weinadega (Mid altitude) and Kola (lowland)
Major constraints

Farmers’ priority for the production of food crops

- Farmers are reluctant to share a plot of land for improve forage production. This is mainly due to economic factors and due to lack of knowledge;
- Dwindling size of grazing lands due to its conversion to crop production, which is associated with increasing human population that demands land for crop production; and
- Farmers who are involved in forage seed production benefited highly from sale of forage seeds, cuttings, and splits. However, scaling up activities of the sector has been poor and has not been done as fast as possible.

Less attention by stakeholders to forage crop and seed production

- Role and commitment of extension workers and researchers working in livestock production in general and animal feed production and distribution in particular has been minimal; and
- Attention given to livestock in general and forage seed production in particular as compared to crop production by government bodies and policy makers of the country has been quite trivial.

Shortage of forage seeds and planting materials

- There is no forage seed producing organization in the region and the country currently. The Ethiopian seed enterprise is the only seed-producing organization which is engaged in the production of seeds of selected food crops only. So there is serious shortage of pasture seeds in the region as well as in the country; and
- There are three source for basic forage seed, i.e., from ILRI, research centers and private seed collector. However, the supply and demand is not balanced. Therefore, availability of forage seeds and seedling production limits the vast expansion of improved pasture and development and the region and the country at large.

Seed Production and Distribution

Most of the improved tropical forages adapted to the environmental conditions of the SNNPRS have no problem of flowering and seed setting. Small quantities of seeds are often collected from 143 Ministry of Agriculture and Rural Development (MoARD) seed multiplication centers and distributed to farmers. The region has a good potential in producing improved forage species having high biomass quality and seed yield. However; the demand and supply are not balanced (Table 4).
A number of projects were involved in forage seed production and development in the mixed crop-livestock systems in SNNPRS; the recent ones include the Fourth Livestock Development Project, the Smallholder Dairy Development Project (SDDP), and the Eastern Africa Agricultural Productivity Project (EAAPP). Activities included improvements in natural pastures and crop residue utilization, feed conservation practices, and introduction of improved forages using different strategies. Introduction of improved forages was facilitated through these projects and used government nurseries for multiplication and seed production. However, the success of these projects in developing a market-oriented livestock production system that responds to adoption of feeds technologies remains to be determined. Recent trends however, indicate that there is a renewed interest to introduce improved forages for feed and seed production and natural resources management in various parts of the region. Requests by Woredas and Zonal rural development bodies, non-governmental organizations (NGOs) and the private sector for forage seeds and cuttings from MoARD seed multiplication centers, and forage germplasm collections has increased over the last five years. The total amount of disseminated forage seeds from the year 2005 to 2010 increased.

Table 4. Annual estimated forage seed demand and supply (quintals) in the year 2005 to 2010 in the SNNPRS

<table>
<thead>
<tr>
<th>Forage seed</th>
<th>Demand for the 5 years</th>
<th>Supply for the 5 years</th>
<th>Current demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasses</td>
<td>100 – 150</td>
<td>About 10</td>
<td>50</td>
</tr>
<tr>
<td>Legumes</td>
<td>200 – 230</td>
<td>About 15</td>
<td>100</td>
</tr>
<tr>
<td>Browse</td>
<td>10 – 25</td>
<td>10</td>
<td>3-5</td>
</tr>
<tr>
<td>Fodder beet</td>
<td>5 – 8</td>
<td>2-3</td>
<td>5</td>
</tr>
<tr>
<td>Elephant grass</td>
<td>2,000,000-5,000,000 cuttings</td>
<td>5,000,000 cuttings</td>
<td>5,000,000</td>
</tr>
<tr>
<td>Desho grass</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Southern Region Bureau of Agriculture and Rural Development; SNNPRS = Southern Nations Nationalities Peoples Regional State

The dissemination of Napier grass and Desho grass increased from 2 million in 2005 to about 5 million cuttings in 2010. These figures should be taken with caution as they relate only to requests to MoARD and additional materials could have been supplied from other sources. In addition, apart from increasing trends in requests, data on the use of these materials under farm conditions are not available. Data regarding other feed improvement operations including efforts on natural pasture improvements in various parts of the region are not available. In addition, the involvement of the private sector in forage feed production has been limited as the market at farmers level for these resources has not yet been developed.
Seed Distribution Schemes

The dominant forage seed production and distribution schemes that supply seeds to farmers of the SNNPRS are ILRI and research centers, MoARD seed multiplication centers, farmer to farmer or Zones to Zones and Woredas production and distribution schemes. Regional forage seed cleaning and grading center is on construction to begin the forage production and distribution schemes of the region.

Roles of Actors in Forage Seed Production

- **Contract farmer seed producers**: produce seed and sale it based on agreement to other farmers or distributors or traders;
- **Southern Region Bureau of Agriculture multiplication centers** (143 sites): mostly concentrate and produce seeds that cannot be produced by farmers;
- **Private trader (Zegba)**: collect seeds and sale to users; and
- **Hawassa Research Center**: produce seed on-station and on-farm for maintenance, as well as collect seeds and distribute small basic seeds to users.

Constraints

Constraints for forage seed production and distribution in the region can be many, and the main important ones are noted below.

- Shortage of commercial forage seeds be at governmental or private level like other food crops;
- The absence of regulatory framework/standard/ and responsible body for forage seed production, importation and distribution;
- Lack of incentives to encourage private firms to involve in forage seed production and distribution;
- Knowledge gap in forage seed production, storage, distribution and quality control at all stakeholder levels; and
- Lack of equipment suppliers for seed cleaning, grading, and the like for to encourage one to embark business in the area and also to do appropriate research and deliver appropriate or quality seeds

Conclusion and Recommendations

This workshop is highly valuable to all stakeholders who are involved in forage seed production and development. People from various organizations and regions would exchange ideas and information that would help redesign alternative seed production options, dissemination system and strengthen the
existing forage seed production in Ethiopia. Forage seed dissemination mechanism is more of informal and managed by traditional seed sector that lead to beneficiaries’ access to seeds of poor quantity and quality. There is insignificant contribution of the formal seed sector for forage seed production, and markets and marketing system is poor for forage seeds, despite the increasing demand for seed production in the region. Therefore, farmers training centers should have to be exploited for demonstration and multiplication of forage seeds, capacity building and strengthening knowledge and skill of the farmers in seed production should be done, research-extension linkage should be enhanced to promote proven technologies in the area, and networking and information exchange is vital to successful forage seed production and marketing in the SNNPRS. All stakeholders should also be committed to work hand in hand to solve the striving problem in forage seed production and distribution in the country.

References

Forage Seed Production and Supply in Tigray

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Introduction

The major feed resources in Tigray Region are natural grazing and crop residues supplemented by hay and weeds whose productivity depends on the rainfall intensity. Limited availability, seasonal variability, and poor quality of feeds are widely perceived as the most limiting factor in smallholder dairy production (Tsigeweyni, 1997; Tesfaye et al., 2010). On dry matter basis, crop residue is the major feed type (34%) followed by natural grazing (31%) (CACC, 2003). Arable lands are also used as communal grazing areas during the dry season immediately after harvest (Berhanu et al., 2002). Thus, livestock are allowed into the cropping land for aftermath grazing. Cactus pear which is also popular in the mid and highlands of Tigray is used as forage for livestock especially in eastern and southern zone of the region during drought seasons. Similar to the report of Yoseph et al. (1999), in urban and peri-urban dairy farms of the Region conserved hay is the major basal diet. Agro-industrial by-products and commercial concentrate rations are used in some dairy producers owning crossbred dairy cows and fed as supplement to roughage-based diets. Non-conventional feeds such as hulls of pulses and other cereal crops, traditional brewery by-products (atela) are also utilized mainly for dairy animals. Only 0.15% of rural livestock holders reported on-farm production of improved forages like alfalfa and Napier grass (CSA, 2008).

Due to the un-reliable and erratic rainfall pattern and the small land holding of the farmers in Tigray, feed scarcity is the primary constraint to livestock productivity in crop-livestock mixed farming systems. The annual feed shortage or gap in the country is estimated to be 41% (Fekede, 2008). Feed availability is among the constraints that significantly limit livestock performance in the smallholder farms in the northern highlands of Ethiopia (Haileselassie et al., 2009). This is reflected in terms of both the insufficient amount and poor quality of feeds available during most parts of the year particularly the dry season (Yayneshet et al., 2008). Free and uncontrolled grazing is the dominant grazing system in Tigray region and is one of the major problems for sustainable agricultural development in the mixed-farming system of the region (Berhanu et al., 2002). Due to the above-mentioned problems, the available feed resources only fulfill the maintenance requirement of the animals for greater part of the
year and the critical feed shortage occurs mainly from March to July. It is therefore, important to modernize the traditional livestock management especially the feed and feeding system to bring change in animal productivity and production.

Improving animal nutrition using cultivated forage species is an important step in supporting and improving livestock productivity (Mengistu, 1999; Alemayehu, 2004; Abebe, 2008). Conservation of high quality exotic forage species would provide a source of dry season supplementation and improve the productivity of grazing animals. For this reason, based on the “conservation based forage development strategy”, the Regional Bureau of Agriculture and Rural Development, together with different non-governmental organizations (NGO’s) has been implementing different forage development interventions for the last two decades. However, the impact of the forage seed supply and multiplication for forage development are not studied in detail and well documented. This paper, therefore, aims to review the past and the current experience of forage seed supply and forage development of the region along with its limitations/constraints and implications within the context of solving feed shortage and improving livestock management.

**Forage and Pasture Crops Grown in the Region**

**Multipurpose tree legumes**

Among the tree species, Sesbania, Leucaena and pigeon pea are well established in different forage development strategies in all agro-ecologies of the region. Leucaena is mostly grown in low altitude but also perform well in mid altitude of the region. Tree Lucerne (tagasaste) is only found in some high altitude areas. The other tree legume introduced recently in limited districts is saltbush. Suitable establishment strategies for the above major tree legumes are along strips, planting for grazing land rehabilitation, in backyards, in treated gullies for dual purpose. Except for other basic seed or new variety, currently there is no shortage of seed for sesbania, leucaena, and pigeon pea in the region. However, the region still needs and has shortage of Tree Lucerne and saltbush.

**Herbaceous forage legumes**

Cowpea, lablab, vetch, and alfalfa are the major forage legumes well adapted and planted mainly by farmers. Cowpea and lablab are also used as human food. Mostly, farmers plant such legumes by intercropping with maize or sorghum. In some cases forages especially alfalfa are planted in free plots to supplement dairy cattle feeds. For the purpose of seed production, alfalfa is grown in nursery site because of its difficulty for seed production at farmer’s level. Cowpea and alfalfa are well familiarized and planted by many farmers. The demand for alfalfa by farmers or investors is increasing due to its supplementary effect in dairy and fattening mainly in the urban and peri-urban areas. Where there is
good moisture, the forages perform well and seed production is promising. Even production of alfalfa seed at smallholder farmer level is started. However, due to drought and other management factors, the region currently has seed shortage for vetch, lablab, and alfalfa in their order of their demand. Other forage legume species such as stylo, deismodium, axilaries and siratro species are neither known by farmers nor widely distributed. They are limited in nursery sites and seed production of these species was difficult. However, promising results were observed in some closed grazing lands sown as mixed pasture long before 5 to 7 years.

**Grass species**
The dominant grass species well suited and familiarized in the region are Napier (Elephant) grass, Rhodes grass, and phalaris in the order of their dominance (Table 1). They are widely planted and utilized especially in soil and water conservation structures and closed grazing lands. Today, except for any other new variety, there is almost enough source for cuttings of Napier grass for plantation. As there is difficulty in seed production and harvesting, productivity is mostly low for rhodes and phalaris seeds and thus there is always shortage of seed for these grass species. Other grass species such as buffel, colombo, panicum and bana are only introduced for adaptation trial in nursery sites. All these species are not widely distributed beyond the nursery sites but are rarely planted for biological soil and water conservation measures.

The major forage development strategies exercised in the region (BoANRD, 2008) are:

- Development of forage strips or alleys (mainly sesbania, pigeon pea. Tree Lucerne, Phalaris and Napier grass);
- Establishment of backyard forage plots (mainly alfalfa, rhodes, napier grass and all tree legumes);
- Improvement of stock-exclusion areas (all grass species mainly Napier, Rhodes and Phalaris);
- Under sowing of legumes into annual crops (cowpea, lablab and vetch);
- Sowing of perennial forage legumes under perennial tree or fruit crops (alfalfa mostly in irrigable areas);
- Establishment of perennial mixed grass/legume pasture (in closure grazing lands); and
- Establishment of forage legumes and grasses in treated gullies from grazing and as biological soil and water conservation (all grass species mainly Napier grass and tree legumes).
Table 1. Major pasture and forage species grown in Tigray region

<table>
<thead>
<tr>
<th>Forage Species</th>
<th>Relative abundance</th>
<th>Established strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Napier grass</td>
<td>++</td>
<td>Gully treatment, SWC structures, Backyard, closure areas, irrigation sites</td>
</tr>
<tr>
<td>Phalaris</td>
<td>+</td>
<td>Over-sowing in pasture lands, SWC structures, and closure areas</td>
</tr>
<tr>
<td>Rhodes</td>
<td>++</td>
<td>Over-sowing in grazing lands, SWC structures, and closure areas</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>++</td>
<td>Back yard, under perennial plots, irrigation sites</td>
</tr>
<tr>
<td>Cowpea</td>
<td>++</td>
<td>Under-sowing and free plot</td>
</tr>
<tr>
<td>Vetch</td>
<td>++</td>
<td>Under-sowing and free plot</td>
</tr>
<tr>
<td>Lablab</td>
<td>+</td>
<td>Under-sowing and free plot</td>
</tr>
<tr>
<td>Sesbania</td>
<td>++</td>
<td>Under-strips (alley) strips, gully treatment, SWC structures, Backyard, closure areas, irrigation sites</td>
</tr>
<tr>
<td>Leucaena</td>
<td>++</td>
<td>Under-strips (alley) strips, gully treatment, SWC structures, Backyard, closure areas, irrigation sites</td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>++</td>
<td>Under-strips (alley) strips, gully treatment, SWC structures, Backyard, closure areas, irrigation sites</td>
</tr>
<tr>
<td>Tree Lucerne</td>
<td>+</td>
<td>Under-strips (alley) strips, gully treatment, SWC structures, Backyard, closure areas, irrigation sites</td>
</tr>
<tr>
<td>Saltbush</td>
<td>+</td>
<td>Under-strips (alley) strips, gully treatment, SWC structures, closure areas</td>
</tr>
</tbody>
</table>

* It is specific to the highland; ** Introduced very recently; SWC: Soil and water conservation

Forage Seed Schemes

**Nursery sites**
Nursery sites are the main scheme for forage seed production and promotion. Since 1993 about 25 forage seed multiplication nursery sites have been established in different agro-ecologies with the size of 0.75-1.5 hectares in the region. They have been used for adaptation, demonstration and seed multiplication purposes. Major forage species grown and multiplied are grass species and perennial legumes. The seeds are then distributed to individual farmers. However, nursery sites do not produce as much of their potential due to management and financial problems. Most of the nursery sites have shortage of skilled human power as well as daily laborers. They are not well equipped with necessary materials. Some of them have shortage of water. Previously, they were also supported by the National Livestock Development Project (NLDP), but today budget is only allocated for labor or technicians as well as guards in the form of grain or in cash. Otherwise, there is no permanent budget. At present only 18 are active others are closed due to budget constraint. Experience shows that there is no problem of producing different forage species in the region but
the issue of their sustainability remains questionable, for they lack strict follow up and evaluation and other related reasons.

**Contract seed production**
The successful, economically profitable, and feasible method of producing large amount of forage seed locally at a lower price is under contract with individual farmers and/or co-operatives. Another advantage is to create awareness on improved forage species over a wide range of ecological locations so that farmers can retain their own seed for subsequent sowing. The Bureau provides seed for initial sowing. Regular visits are made to ensure that crops are properly managed and seeds are harvested at the right time, and then purchase made on agreed terms. Farmers grow and manage the seed, harvest and deliver clean seed. Farmers have the responsibility of returning the amount of initial seed they took.

Previously, a contract price was set based on cost of production and estimated yield. The revised price also considers the current monetary value, the price by which suppliers or producers sell in the local market or supply to the Bureau purchased by bid. The contract is targeted on specific forage legume seeds such as cowpea, lablab, and vetch species that can be easily produced by farmers. Today, alfalfa seed is also produced by some farmers. However, the seed production contract is a legally binding agreement between the Bureau and the farmer but practically it is made in favor of the farmers for the sake of encouragement. From experience, farmers are not usually obliged based on the agreement when there are some misunderstandings or circumstances. The contract is attractive to most farmers. Because, they get reasonable and predetermined or fixed price for each forage species and as such do not face market problem. It is easy to produce, and forage seed production is unlikely to compete with production of other food crops. Usually the area cultivated by an individual farmer to produce forage seed is 0.25 hectare, although some farmers cultivate up to 2 hectares. Mostly they under sow to maize and sorghum but some of them sow on free plots. Beside the limited budget, a problem that decrease forage seed yield is due to failure of timely planting, disease, and pests during flowering stage, as well as drought. Under this condition, some farmers feed it to animals at green stage or only harvest some seed for themselves. The Bureau does not recommend farmers to produce other forage seed types other than cowpea, lablab, and vetch.
Farmers training center (FTC)
One mechanism of forage seed production is using FTCs. They are now serving as an entry point for scaling out/up forage development. Parallel to adaptation and demonstration activities, significant amount of forage seeds are harvested from FTCs and distributed to nearby farmers. The major forage seed types harvested from FTCs are cow pea, vetch and multi-purpose tree legumes (*Sesbania Spp.*, *Leucaena Spp.* and *pigeon pea*). But, the numbers of FTCs that produce forage seed are few.

Opportunistic seed collection
Seed is also harvested and collected from forage plots and areas established primarily for other purposes. Apart from the contract scheme, the Bureau purchases any seed collected from forage development sites. Multi-purpose tree legume and grass seeds are opportunistically harvested from stock-exclusion areas forage strips and treated gully sites. Not only improved (exotic) forage species but also seeds of local grass species are also collected annually and re-sown as biological soil and water conservation, and for improving degraded grazing lands. Seeds of Rhodes, and multi-purpose tree legumes (*Sesbania*, *Leucaena*, and *Pigeon pea*) are the major seeds collected. This scheme also is used as source of cuttings of Napier grass.

Importing/purchasing seeds
At this time, the above forage seed production schemes are not satisfying the forage seed demand. Therefore, the other alternative seed source supply is importing or purchasing seed (planting material) from any source outside the region or outside the country (Table 2). It is at this stage that the non-government organizations (NGOs) or actors can play their role. Hence, forage seeds are introduced by the Bureau and other stakeholders to the region annually. The major problem often exhibited in this regard is the question of purity and introduction of unknown seeds and diseases.

**Table 2. Summary of forage seed production schemes**

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Production year and seed produced (Qt)</th>
<th>Major Forage Species Produced (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2006 2007 2008 2009 2010</td>
<td>Grass</td>
</tr>
<tr>
<td>Nursery Sites</td>
<td>27 31 55 62 50</td>
<td>65%</td>
</tr>
<tr>
<td>Contract Produce</td>
<td>251 252 256 35 112</td>
<td>100%</td>
</tr>
<tr>
<td>FTC</td>
<td>0 3 5 13 18</td>
<td>90%</td>
</tr>
<tr>
<td>Opportunities</td>
<td>23 15 17 20 22</td>
<td>65%</td>
</tr>
<tr>
<td>Purchase/Import</td>
<td>94 101 117 85 141</td>
<td>55%</td>
</tr>
<tr>
<td>Total</td>
<td>395 406 450 215 343</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Compiled from annual reports of the Tigray Bureau of Agriculture.*
Annual Forage Seed Demand and Supply Trends

Since forage seed system in the country as well as in the region is not well developed, the needs of farmers for forage seed is little known. Therefore, it is difficult to quantify demand for fodder seed by independent smallholder farmers. Although there are some efforts in some woredas, the experience of collecting and summarizing forage seed demand still is a concern of the Bureau and different stakeholders to improve the feed problem. The supply of forage seed to farmers by both governmental and non-governmental organizations at subsidized rates or freely was and is still a problem to identify the supply trend and establish stable market. Demand for forage planting material is increasing by farmers who are engaged in dairy or fattening programs.

The availability of other alternative local feed sources is another factor that affects the demand for improved forage seed. In the presence of good rainy season, there are local grass species such as Cynodon dactylon and local tree legumes such as Balanites aegyptica, Ziziphus spinacristi and Shebaka. During this period farmers demand for improved forage species becomes second priority. The current uncontrolled or continuous grazing system is another factor affecting growing of forages and pastures crops. In an area where there is closed grazing land and controlled or zero grazing (cut and carry systems), one can observe that exotic forage crops are well established and utilized, and the demand of farmers’ for such forage crops increase.

Forage seed demand is annually estimated based on the forage development intervention of the Bureau and different organizations or stakeholders. This is by considering their individual program or plan in seed supply to be planted in different activities such as for rehabilitating grazing lands, soil and water conservation measures, gully treatment, irrigated lands, and to be distributed for target households for under-sowing or for backyard forage development. Generally, the supply of forage seed is always below the demand (Table 3), which is a challenge to forage development program. However, there are some improvements from time to time.
Table 3. Demand and supply of forage seeds (annuals), planting materials, and seedlings

<table>
<thead>
<tr>
<th>Year</th>
<th>Seed (q)</th>
<th>Cuttings (No in 10 thousands.)</th>
<th>Seedlings (No in 10 thousands.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Demand</td>
<td>Supply</td>
<td>Demand</td>
</tr>
<tr>
<td>2006</td>
<td>790</td>
<td>395</td>
<td>200</td>
</tr>
<tr>
<td>2007</td>
<td>1000</td>
<td>406</td>
<td>250</td>
</tr>
<tr>
<td>2008</td>
<td>1200</td>
<td>450</td>
<td>300</td>
</tr>
<tr>
<td>2009</td>
<td>1400</td>
<td>215</td>
<td>300</td>
</tr>
<tr>
<td>2010</td>
<td>1500</td>
<td>343</td>
<td>450</td>
</tr>
<tr>
<td>Total</td>
<td>5890</td>
<td>2225</td>
<td>1500</td>
</tr>
</tbody>
</table>

Source: Compiled from the Bureau of Agriculture and Rural Development Annual reports

Actors and their Roles in Seed Production

This section aims to identify some of the initiatives conducted or those in progress by different actors towards forage seed production and supply. There are some actors who play a complementary facilitator role regardless of their capacity, size of the area they cover and time of start. They are involved in all areas of forage development programs such as supply of seed and/or planting material, capacity building, financial and material support, training, and experience sharing, establishing nursery site, and linking forage market with livestock commodities (Table 4). Generally, they all are contributing and have initiatives towards feed improvement but their regional integration or linkage is low. The major non-government actors (projects) involved in the region is explained below.

Relief Society of Tigray (REST)
REST is a local non-government organization involved in forage development activities in the region. The organization had introduced different forage seeds from abroad. The main strategy of REST is increasing feed biomass through area closure and rehabilitation, gully treatment, and grazing land enrichment. It is also involved in capacity building, financial and material support to nursery sites. The organization also collects different local grass species annually for rehabilitation activities. Now, REST is undertaking its activities in twelve Woredas of the region.

World Vision Ethiopia (WVE)
This project is probably the second actor in relation to its duration of intervention in forage seed production in eastern parts of the region. Now it expands its coverage to southeastern and southern zone woredas of the region.
The project is involved in capacity building, supply of forage seed, capacitating (material supply and budget for cost of daily laborers) of the nursery site. Different forage seeds were supplied through purchase to the project Woredas via the district office of agriculture.

**Sustainable Land Management Program (SLMP)**

Sustainable Land Management Program (SLMP) in Tigray is a recent and very active project working in twenty two Woredas on 40 watersheds. The core advisory unit of SLMP deals with the scaling up of watershed development practices through institutional capacity building, promotion of innovative technologies, systems and approaches and provision of initial inputs and strategic materials. As such provision of necessary initial inputs during initial adoption of planting materials and seeds such as Saltbush, *Pigeon pea*, Sunflower and grass splits were introduced and demonstrated in different agro-ecological areas. Different forage species were selected and strategically introduced for the purpose of gully treatment, animal feed and as bee forage. The project focuses on *Pigeon pea* and *Saltbush* (from tree legumes); on *Pennisetum glaucum* (*Bana grass*) and *Syngonanthus nitens* (*golden grass*) and Napier grass from grass species. *Cassia sturtii* and Sunflower were selected for the purpose of bee forage by the project.

In 2010, about 1 quintal saltbush, 20 quintal *pigeon pea*, 20 quintal sunflower, 300,000 cuttings of elephant grass, 250,000 splits of *Bana grass* were distributed to the watersheds of the project. The project has also introduced cuttings of dwarf Napier grass variety (140,000 cuttings). Source of forage seeds are from Australia (saltbush), from private seed producers (North Wollo zone of Amhara region), and from nursery site established and managed by the project. The nursery was used as an adaptation and multiplication trial of forage seeds which helps to increase sustainability of seed supply. Currently the nursery produces quality seeds of saltbush and *pigeon pea*. Moreover, the project assists farmers training to engage in income generating activities and provide technical broachers printed in English and Tigrigna version.

**Helvetas-Ethiopia, Beles SUNRise Project (BSP)**

Helvetas-Ethiopia under the BSP is promoting forage development in six sites of five Woredas located in the Eastern and Southern zones of Tigray. Forage development is integrated with the project intervention components that include community and institutional capacity building; community based participatory watershed development, beles development, and family farm and homestead development. The major strategies of forage development are productive use of hillsides and gullies, developing of degraded pastures/grazing lands and forage production on family farms and cash bunds.
In 2010, BSP has planted more than 25,000 saltbush seedlings integrated with beles planting on hillsides of the project sites through active participation and sense of ownership of the beneficiaries. In addition, seeds of various forage legume crops including cowpea, pigeon pea and lablab were introduced to selected farmers and were planted as under-sowing and on cash bunds. In 2011, the project is making various preparations for scaling up the forage development activities by producing plant material of legume and grass seeds, seedlings of saltbush, moringa, Tree Lucerne and other perennials and elephant grass cuttings. So far more than 10 quintals of seeds and about 0.5 million cuttings of different forage species mainly drought tolerant and multipurpose varieties are produced in the project nursery for the coming cropping season. The scaling up intervention is supported with capacity building and community empowerment through experience sharing on best practices of the region, organizing trainings and institutional supports. Participatory planning and decision making processes, adoption of zero grazing, hillside land allocation to individual users, organizing community development groups, and establishment of watershed associations are the key components of BSP that are currently under implementation to achieve the objectives of the project including attaining livestock feed security in the intervention areas.

Improving productivity and market success (IPMS)
Since 2005, IPMS carried out considerable activities on market oriented livestock development in general and linking forage development with livestock commodities in particular. The activities on forage development include: supplying seed or planting material, rehabilitating grazing lands, capacity building for experts, farmers trainings and experience sharing, organizing workshops, and promote market linkage. Since the start of the project, more than 40 quintals of seed of grass species such as phalaris, Rhodes, cuttings of Napier grass, Panicum, Desho grass and different legume species are supplied and/or introduced to the project areas in collaboration with the Woreda Office of Agriculture. After the first introduction of seeds, the key target was to multiply and harvest seed to be distributed to farmers for back yard forage production, for rehabilitating grazing lands, and area closures. IPMS’s seed source was ILRI, REST, BoARD and Melka Werer Agricultural Research Center.

IPMS identified FTC as the best entry point for seed multiplication, in addition to forage nursery sites. This reduces transportation and other costs, and can be used to recommend and identify at grass root level suitable species based on its adaptability. For example, about 1800 cuttings of virus free Napier grass was distributed to 3 FTCs and about 28000 virus resistant cuttings were harvested and distributed to farmers. Similarly, seed of phalaris grass was harvested from the previously rehabilitated grazing lands; and nursery sites especially in Alamata.
In the project areas, introduced forage species especially phalaris, Napier grass and recently introduced Desho grass were well adapted and increased feed biomass. Different forage legumes were familiarized to farmers. In Alamata, seed production of cowpea and lablab is being started by private investors before two years. Generally, the promotion of different forage seeds showed promising result in increasing feed biomass and as source of seed for conservation measures in watershed management activities. Forage groundcover improved to about 70-100% after intervention as compared to the 20-30% before intervention (Azage et al., 2009).

**Social and Development Coordinating Office of Adigrat Diocesan Catholic Secretariat (ADCS-SDCO)**

The ADCS-SDCO is contributing towards forage development in the eastern part of the region. The project involves capacity building, supply of forage seed, and capacitating material supply and budget for cost of daily laborers of the nursery site. Different forage seeds are supplied through purchase to the project Woredas via the district office of agriculture but the quantity is quite low.

**Agricultural Cooperative Development International /Volunteers in Overseas Cooperatives Assistance**

The Feed Enhancement for Ethiopian Development (FEED) project of ACDI-VOCA started since 2009 for enhancing feed development by supporting farmers through unions and cooperatives. The project involves capacity building and supply of forage seed in four Woredas of the region.

### Table 4. Summary of actors involved in forage seed supply

<table>
<thead>
<tr>
<th>Actors</th>
<th>Activity started</th>
<th>Number of Woredas Covered</th>
<th>Major activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>REST</td>
<td>1993</td>
<td>12</td>
<td>FA, MS, CP, FPMS</td>
</tr>
<tr>
<td>WVE</td>
<td>1996</td>
<td>6</td>
<td>FA, MS, FPMS</td>
</tr>
<tr>
<td>HELVETAS</td>
<td>2010</td>
<td>5</td>
<td>FA, MS, FPMS</td>
</tr>
<tr>
<td>SLMP</td>
<td>2009</td>
<td>22</td>
<td>CB, FPMS</td>
</tr>
<tr>
<td>IPMS</td>
<td>2005</td>
<td>2</td>
<td>CB, FPMS</td>
</tr>
<tr>
<td>ADCS</td>
<td>1995</td>
<td>7</td>
<td>FA, MS, CP, FPMS</td>
</tr>
<tr>
<td>ACDI-VOCA</td>
<td>2009</td>
<td>4</td>
<td>MS, CP, FPMS</td>
</tr>
<tr>
<td>FA</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FA-Financial aid, MS-material support, Capacity building, Forage planting material

Source: Summarized from the activities of respective actors (report and expert interview); REST = Relief Society of Tigray; WVE = World Vision Ethiopia; SLMP = Sustainable Land Management Program; BSP = Helvetas-Ethiopia, Beles SUNRise Project; IPMS = Improving productivity and market success; ADCS = Adigrat Diocesan Catholic Secretariat; ACDI-VOCA = Agricultural Cooperative Development International /Volunteers in Overseas Cooperatives Assistance
Constraints of Seed Production and Dissemination

Forages have much lower and exposure profile than major food crops within the region. Though the Bureau and other organizations/actors have done a lot of efforts, sustainable seed production is not yet realized. Only small farmers, today, have access to or use forage seeds. There are different problems that constrain seed production and dissemination. Low integration of research and dissemination, low technical skill, and low attention given towards to forage seed production are the major constraints in the region.

- **Low research on forage seed production system**: Adaptability and productivity for each introduced forage crop is not well studied and problems are not clearly identified. This is not also supported by community-based research. Most of the activities were towards introduction and familiarization focused on specific forage species.

- **Low regional capacity building for forage seed production**: Very small or no budget is allocated to forage nursery sites today. Hence, forage nursery sites are not yet well equipped with necessary materials, skilled labor, and have storage problem to maintain viable seed in good condition. Of the present nursery sites only four have small sized store and thus are very crowded as they serves as a store for all the nursery equipments and as guard house.

- **Poor seed quality control**: Certification activities for forage seeds are not well developed. Every actor introduces different types of forage seeds regardless of its variety and generation. Quarantine and evaluation mechanisms for forage seed is almost none, except simple control mechanism to its physical purity and germination. Hence, there is lack of information about the seed source and flow at regional level.

- **Disintegrated seed supply system**: Though there are various isolated activities of development programs made by governmental and non-governmental organizations, an integrated seed supply system has not been developed. Forage seed supply plans are not integrated in temporal and spatial terms.

- **Low participation of investors on forage seed production**: As marketing of forage seed is not yet developed, farmers see its profitability and prefer human food crops because it has an established market demand. Where there is an awareness and interest by some investors to produce more forage seeds, they are not encouraged by the regional predetermined forage price. Though it is revised now, the past fixed price used for more than fifteen years discouraged farmers to produce seed by contract. Therefore, the absence of potential forage seed producers and suppliers is another problem.

- **Technical problem**: Farmers and experts as well lack knowledge on seed harvesting, processing and storage and potential uses of suitable forage species.

- **Extension problem**: There are shortcomings in identifying beneficiaries that use forage or produce improved forage species. Besides, suitable or appropriate forage development strategy is not clearly identified. It is very much less integrated with dairy and fattening.
• **Uncontrolled and continuous livestock grazing:** Because, in areas where there is controlled grazing system or cut and carry system, forage species are seen well established. However, as farmers use uncontrolled and continuous livestock grazing, it is hard to promote and establish improved exotic forage species.

• **Annual free charge of forage seed:** This makes many farmers not to produce and collect seed.

• **Recurrent drought:** It is a chronic problem in the region to promote different forage crops mainly to produce and harvest forage seeds.

**Conclusion**

Unless the uncontrolled and environmentally un-friendly livestock management system is modernized, the productivity and production of the sector will continue to be low. Therefore, promoting and improving forage development and forage seed production is a key enhance livestock productivity. To improve the feed resource base, the Bureau and other development organizations have been promoting a number of improved forage species on various development strategies since the last two decades. Regardless of low stakeholders/actors integration, there are promising successes for further forage development activity. With limited interventions, forage development packages are achieved effectively in watershed management areas and irrigation schemes. Farmers involved in dairy and fattening; appreciated the importance of improved forage species and demand seed for these species. Some adaptable forage species such as Napier grass and Cowpea, which have multiple uses are promoted, and popularized to farmers through integrating forage development with soil and water conservation or cropping system; and in some areas linking forage development with commercial dairy and fattening. In general, adoption of forage species by individual farmers is still low. The current farmers’ demand for forage seed is much difficult to quantify except for some practices in active project areas/schemes. Past efforts concentrated on introduction and plantation of different forage species. Little has been done on developing and organizing to create sustainable seed production. Low integration of research and dissemination, low technical skill, and low attention towards forage seed production are the major constraints in the region. Therefore, there is still shortage of forage seeds especially grass species and small sized legume seeds.

**Recommendations**

• Instead of isolated activities, integration of multiple stakeholders (NGOs) involved in forage development is important to facilitate and forward adoption of forage seed;

• It is important to develop and use alternative means of seed supply. Emphasis should be given to contractual seed multiplication by individual farmers and investors with annual revision of seed price. Government-owned seed production schemes or activities should be encouraged and continued by identifying and
selecting best effective and potential nursery sites. This helps to adapt, produce and supply different forage seeds until the forage seed multiplication is well invested up on by private sectors or cooperatives. Capacitating FTCs because of their potential for forage seed production need to be encouraged;

- Promoting forage seed marketing systems is important. Farmers should pay reasonable price for any seed they use, because over-subsidizing creates dependency. The other mechanism may be a rotating fund to promote both seed production and marketing;
- Linkage of forage development with livestock based commodity is crucial because dairy expansion, fattening, and feed commercializing are an entry point for enhancing seed supply;
- Forage development strategies should focus on watershed management schemes, soil and water conservation structures and irrigation sites;
- To promote an organized forage seed system, building the capacity of seed producers as well as seed producer organizations on developing agribusiness skills, promotion activities such as market linkage should be strengthened. Environmental requirements for flowering, seed set and seed recovery of forage species is not well known. Hence, research should be strengthened in these areas;
- Improved genetic materials are likely to include new varieties and basic seeds. Research organizations must promote both a technology transfer process and the release of a new material, where supply of basic seed is critical;
- Participatory study should be done on promotion of the value and benefit of forages to farmers, seed production and marketing;
- Comparative study on local forage species should be encouraged to maintain biodiversity; and
- Designing legal quality controlling system and/or legislation is important to control quality standards.

References

Abebe Mekoya. K. 2008. Multipurpose fodder trees in Ethiopia; Farmers’ perception, constraints to adoption and effects of long-term supplementation on sheep performance, PhD thesis, Wageningen University, Wageningen, the Netherlands


Forage Seed/Planting Materials Production

Currently, production of seedlings of fodder tree legume is being carried out both in the government and communal nurseries. Backyard systems are encouraged at small farmer’s level to enhance the production of both green fodder and fodder seeds. Agricultural Research Centers found in different zones of the region are being supplying various forage/fodder seeds/planting materials. However, field programs are constrained by lack of an organized need assessment program and poor supplies of planting materials, and almost invariably by a very limited range of species. Appropriate seed production and supply mechanisms are not in place. Farmers are getting some forage seeds from their accessible farmers (from their neighbor/vicinity). Sometimes the source of the required seed varieties are assessed based on the demand comes from the grass root level (from the farmers). This implies that forage development activities are constrained by poorly developed mechanisms for exchange of ideas and information among the actors. There is also poor coordination at regional level, mainly constrained by budget/funding limitations.

Even though seed production based on contractual agreement was not sustained due to lack of fund for purchases, some Weredas were trying to produce seeds of a few forage varieties, until the recent years. Purchasing, collection and distribution of these materials have been remained within those Woredas. Because it was difficult to get fund and collect it at the center for further redistribution. At farmers level some weredas have been experienced and involved in forage seed production as it is depicted in Table 2.

Annual Forage Seed Demand and Supply

A large-scale forage-development program can be effectively achieved only with the use of adequately available genetic materials, with the implementation of appropriate need assessment program, and with proper coordination and facilitation at different levels for the multiplication of seeds and seedlings. However, all forage production programs in the region are heavily constrained
by poor supplies of planting material and by a limited range of forage seed species and varieties. It was during the aforementioned projects (those which were running forage seed multiplication programs) that need assessment have been conducted yearly. This implies that forage seed production and multiplication activities of the region were very heavily dependent on projects.

**Table 2. Government and non-government institutions used as forage seed suppliers.**

<table>
<thead>
<tr>
<th>Institutions*</th>
<th>Type of seed supply</th>
<th>Purpose</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holetta I Research Center</td>
<td>Oats, Vetch, Tree Lucerne, Rhodes grass and Elephant grass split</td>
<td>Mostly for demonstration &amp; training</td>
<td>Elephant grass For multiplication</td>
</tr>
<tr>
<td>Adami Tulu Research Center</td>
<td>Lablab, Cow pea, Alfalfa, Vetch and Elephant grass</td>
<td>Mostly for demonstration</td>
<td>Elephant grass For multiplication</td>
</tr>
<tr>
<td>Bako Research Center</td>
<td>Elephant grass split</td>
<td>multiplications</td>
<td></td>
</tr>
<tr>
<td>Kulumsa Research Center</td>
<td>Vetch and Oats</td>
<td>Demonstration</td>
<td></td>
</tr>
<tr>
<td>International Livestock Research Institute(ILRI)</td>
<td>Some forage seed species</td>
<td>Supplies as basic seed for Regions on sale</td>
<td>For further multiplication and development at farmers level</td>
</tr>
<tr>
<td>Agricultural Development Bureau (Natural Resource Development process)</td>
<td>Tree legumes</td>
<td>For soil and water conservations</td>
<td>For development on soil conservation structure</td>
</tr>
<tr>
<td>Eden- Field Agri - seed Enterprise</td>
<td>Some forage seed species</td>
<td>Further distribution to the farmers for business</td>
<td>For further multiplication and development at farmers level</td>
</tr>
<tr>
<td>Some NGO's such as GTZ, World Vision, Land O'Lakes are buying from producer &amp; distribute to the farmers.</td>
<td>Some forage seed species</td>
<td>For forage development and seed production</td>
<td></td>
</tr>
</tbody>
</table>

* The above listed institutions are mainly considered as sources of forage seed species to be distributed for the farmers for further multiplication.

For the first time, it is by the year (2010/11) that the existing seed demand at the grass root level is assessed and compiled at Kebele, Wereda, Zonal and Regional levels. Of course, the achievements to meet the demand could be limited due to shortage of sources and supplies. The regional demand for the year 2011 is indicated in Table 3. As to the supply different stakeholders are being informed with the assessed demand and are expected to meet this demand in the coming year.
Table 3. Weredas experienced in contractual forage seed production for redistribution as forage crops using different strategies

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wereda/District</th>
<th>Types of forage seeds produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Harerger</td>
<td>Doba</td>
<td>Cowpea, Pigeon pea</td>
</tr>
<tr>
<td>Qelam Welega</td>
<td>Sayo and dale Wabara</td>
<td>Lablab, Cowpea, Rhodes grass, and Elephant grass</td>
</tr>
<tr>
<td>Eastern Welega</td>
<td>Guto Gida, Diga, Sibu sire, Leka Dulacha, Gobu Sayo, Jima rare and Wayu tuga</td>
<td>Rhodes grass, Oats, Vetch, Sesbania, Leucaena, Cow pea and fodder beet</td>
</tr>
<tr>
<td>Horo Guduru Welega</td>
<td>Jima genet, Horo, Guduru and Abay choman</td>
<td>Oats, Vetch and Rhodes grass</td>
</tr>
<tr>
<td>North Shoa</td>
<td>Gebre guracha, Girar Jarso Kimbibit, Sululta</td>
<td>Oats and Vetch</td>
</tr>
<tr>
<td>Arsi</td>
<td>Bokoji, Limu Bilbilo, Digaluna Tijo</td>
<td>Oats and Vetch, fodder beet</td>
</tr>
<tr>
<td>East Harerger</td>
<td>Fadis, Kombolcha, Gursum and Meta</td>
<td>Cow pea, Pigeon pea, Vetch</td>
</tr>
</tbody>
</table>

Table 3. Demands for different forage/fodder seeds

<table>
<thead>
<tr>
<th>Forage</th>
<th>Amount of seed (q)</th>
<th>Forage</th>
<th>Amount of seed (q)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vetch</td>
<td>612</td>
<td>Rhodes Grass</td>
<td>100</td>
</tr>
<tr>
<td>Oats</td>
<td>870</td>
<td>Leucaena</td>
<td>8</td>
</tr>
<tr>
<td>Lablab</td>
<td>370</td>
<td>Sasbania</td>
<td>28</td>
</tr>
<tr>
<td>Cow pea</td>
<td>328</td>
<td>Pigeon pea</td>
<td>30</td>
</tr>
<tr>
<td>Fodder Beet</td>
<td>20</td>
<td>Dismodium</td>
<td>27</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>26</td>
<td>Tree Lucerne</td>
<td>21</td>
</tr>
</tbody>
</table>

Actors of Forage Seed Production

Actors for seed production in the region are not as such considered as bulk producers and suppliers. Federal and regional research centers produce some forage species and deliver in small size to farmers for demonstration and training purposes. The private sectors, like Eden Field Agro-seed Enterprise is delivering the required seed varieties on sales. Small holder farmers are involved in the production of some species of forage seeds for commercial purpose, though it is not coordinated for market supply.

Constraints of Seed Production and Dissemination

- Poorly developed mechanisms for exchange of ideas at all levels; among farmers, kebeles and woredas, and very significantly at regional level. There is also poor coordination between the region and the federal level;
• The level of linkages and interactions among government extension, farmers, research and different NGOs is very limited and not well coordinated.

• Ineffective extension approach:
  ▪ There is very limited appropriate extension material available for field staff;
  ▪ The media are not effectively utilized;
  ▪ There is little technical support for field staff;
  ▪ Exchange visits for farmers and field staff are poorly supported;

• Lack of use and coordination with available stakeholders at grass root level, such as schools for the preparation of planting materials and distribution within local communities;

• The FTC approach is lacking, where in more than 15,900 DAs are involved in field work in the region, there is lack of appropriate orientation and technical support;

• Lack of revolving fund for purchase and re-distribution of forage seeds;

• Limited involvement of forage seed production and supply system by government and non government organizations and inadequate resource allocation for forage production activities;

• Lack of sustainable forage seed supply for users and increasing high prices;

• Heavy dependency of farmers on government and project support (seed supply); and

• Problem of land use system (pasture land are utilized for crop production)

**Conclusion and the Way Forward**

There is no reliable seed production and supply system in the region. In order to reduce the existing gap between demand and supply forage seeds in quantity as well as quality, the regional government and the concerned bodies involved in livestock development programs should give due attention in strengthening forage seed production extension services; conducting the right need assessment; better allocation of resources, especially revolving fund for the production of forage seeds; make contractual agreement with federal and regional seed enterprises, private sector, like Eden-Field Agro-seed enterprise, Co-operatives, Unions, individual farmers. Strong collaboration and coordination among various institutions and stakeholders should also exist. The presence of authorized body for seed importation and adaptation is very essential. Encouraging commercialization of forage seed production business is also very important as to enhance and bring changes in its development.

**References**

Forage Seed Production and Supply of Eden Field Agri-Seed Enterprise

Getahun Haile, Abate Tedla and Bayu Telahun
Eden Field Agri-Seed Enterprise, Addis Ababa, Ethiopia

Eden Field Agri-Seed Enterprise

Involvement of the private sector has a great contribution to the national development efforts. Eden Field Agri-seed Enterprise is thus established in 2008 to contribute to its share through production; processing, packaging and selling of forage and tree seeds for various agro-ecologies of Ethiopia.

The specific objectives of the Enterprise are:

• Engage in production, collection, handling and supply of tree including forest tree and forage seeds;
• Engage in contractual work agreements related to natural resource conservation, and sustainable utilization and management activities and provision of training to stakeholders and consultancy services on natural resource conservation;
• Provide technical assistance and backing for rehabilitation of degraded lands, water shade development and agro-forestry practices;
• Involve in seedling propagation including supply of horticultural plants from seeds, cuttings, tissue culture as well as providing urban arboriculture, parkland management, landscape beautification and other related work;
• Promote seed out growers, and producers to ensure adequate availability of tree and fodder seeds in quality and quantity throughout the country; and
• Engage in import/export activities related to tree and fodder seeds and animal feed supply

Seed Multiplication

Eden Field Agri-seed Enterprise is involved in forage and tree seeds production activities with the main focus of enhancing quality seed supply to farmers and other customers involved in livestock production and natural resource rehabilitation and development endeavours, respectively. Forage seed producing farmers assisted by the local office of agriculture, community groups involved in forage and tree seed production and government institutions such as the national and regional research institutes are the main sources of basic seed for the Enterprise. Forage seed out growing farmers at various sites are provided basic
seeds and fertilizers and related inputs at planting and in turn the seeds produced are collected for further processing and sale, which is a scheme based on the agreement signed between the farmers and the enterprise. The general framework of the seed production operation is depicted in Figure 1.

In order to contribute to forage seed supply in various agro-ecologies, the Enterprise currently undertakes its seed multiplication activities at the following sites:

- Gewane in Afar Region (lowland area);
- Wondo Genet Forestry and Natural Resource College and Eney General Business-Awash Dairy Farm PLc. at Awash Meleka (mid altitude);
- Holetta, Sebu Sere and Aleltu in Oromia Region with farmer out grower under the supervision of the enterprise and Wereda experts (highland areas);
- Dembecha in Amhara Region (highland);
- In addition, seed recovery activities are undertaken at various potential sources such as Bako Research Centers;

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**Figure 1:** Schematic diagram showing the seed production process of Eden Field Agri-Seed Enterprise in Ethiopia
• Again with the objective of expanding activities, there is a plan to start community based forage production program at Fentale and Bosset Irrigation Agricultural Development Scheme located in the Regional State of Oromia;
• Seed production activities are currently under discussions with farmer out grower organized by Land O’Lakes in Arsi and Northern Showa (Fiche); and
• For tree seed collection activities, compounds of various institutions such as schools, churches, community forests, and individual farmer fields are used. In the future there is a plan to make use of government forests as source of indigenous and exotic tree species.

From the regular field assessments, observation is made that the farmers are being benefited much from the sale of seeds that they produce through outgrowing program as this contributes much to their family welfare and livelihood (Table 1). The tree seed production activities have also contributed significantly to environmental rehabilitation initiatives of the government and other stakeholders.

**Partners and Collaborators**

Eden Field Agri-Seed Enterprise is closely working on forage and tree seeds production with various partners as shown below.

• Ministry of Agriculture (at Federal and Regional levels);
• Ethiopian Institute of Agricultural Research (EIAR);
• Ethiopian Meat and Dairy Technology Institute (EMDTI);
• International Livestock Research Institute specifically with, IPMS, FAP-IFAD and forage diversity project;
• Wondo Genet College of Forestry and Natural Resource (WGCoFNR);
• Oromia Regional Livestock Development, Health and Marketing Agency;
• Afar National Regional State - Agriculture Bureau;
• Gewane TVET;
• Ethiopian Animal Feed Industry Association;
• Seed outgrowing farmers in different regions; AND
• Women and youth community groups engaged in tree seed collection.

**Services provided**

• Basic seed supply;
• Technical backstopping;
• Laboratory services;
• Training including participation in workshops/conference and exhibition; and
• Facilitation/linkage with seed out growers/ farmers in various regions
<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grasses</strong></td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td><em>Avena sativa</em></td>
</tr>
<tr>
<td>Rhodes grass</td>
<td><em>Chloris gayana</em></td>
</tr>
<tr>
<td>Guinea grass</td>
<td><em>Panicum maximum</em></td>
</tr>
<tr>
<td>Panicum</td>
<td><em>Panicum antidotale</em></td>
</tr>
<tr>
<td>Buffie grass</td>
<td><em>Cenchrus ciliaris</em></td>
</tr>
<tr>
<td>Napier grass</td>
<td><em>Pennisetum purpureum</em></td>
</tr>
<tr>
<td><strong>Herbacious legumes</strong></td>
<td></td>
</tr>
<tr>
<td>Vetch</td>
<td><em>Vicia dasycarpa</em></td>
</tr>
<tr>
<td>Lablab</td>
<td><em>Lablab purpureus</em></td>
</tr>
<tr>
<td>Cow pea</td>
<td><em>Vigna unguiculata</em></td>
</tr>
<tr>
<td>Alfalaf</td>
<td><em>Medicago sativa</em></td>
</tr>
<tr>
<td>Melilotus</td>
<td><em>Melilotus albus</em></td>
</tr>
<tr>
<td>Desmodium (silver leaf)</td>
<td><em>Desmoduin uncinatum</em></td>
</tr>
<tr>
<td>Desmodium (green leaf)</td>
<td><em>Desmodium intortum</em></td>
</tr>
<tr>
<td><strong>Fodder trees</strong></td>
<td></td>
</tr>
<tr>
<td>Sesbania</td>
<td><em>Sesbania sesban</em></td>
</tr>
<tr>
<td>Sesbania</td>
<td><em>Sesbania aculeata</em></td>
</tr>
<tr>
<td>Pigeon pea</td>
<td><em>Cajanus cajan</em></td>
</tr>
<tr>
<td>Tree lucerne</td>
<td><em>Chamaecytisus palmensis</em></td>
</tr>
<tr>
<td>Leucaena</td>
<td><em>Leucaena leucocephala</em></td>
</tr>
<tr>
<td>Leucaena</td>
<td><em>Leucaena pallida</em></td>
</tr>
<tr>
<td><strong>Other crop</strong></td>
<td></td>
</tr>
<tr>
<td>Fodder beet</td>
<td><em>Beta vulgaris</em></td>
</tr>
</tbody>
</table>
Challenges

The issues below are some of the challenges that Eden Field Agri-seed Enterprise with the stakeholders face in forage and tree seeds production and any efforts along seed development in the country should take these issues into consideration.

- Poor linkage among stakeholders and scarcity of innovation system on seed production;
- Lack of adequate knowledge on forage seed production techniques;
- Limited seed processing and seed storage facilities to deliver quality seed;
- High price of forage seed for farmers (due to production cost, lack of basic seed, lack of cleaning facilities, transportation cost etc.);
- Lack of financial support mainly from bilateral and multilateral donors for the private sector involved in seed production;
- Low awareness on forage seed crop husbandry and lack of support and incentives;
- Low attention on policy issues related to livestock development in particular on forage seed production;
- Mother trees for seed production found at present are in most cases of inferior quality since the best quality trees are selected and removed for other economic purposes;
- Inadequate supply of basic seeds for various species;
- Market uncertainty and price fluctuation on forage seeds; and
- Lack of regulations on seed quality

Conclusions

While Eden Field Agri-Seed Enterprise is involved in forage seed production in various agro-ecologies, much is expected to be done in the country and hence joint efforts and support consideration should be given by all concerned for seed technology to deal with the complex issues and activities of seed production in order to meet the seed demand, to bring change and promote forage development.

References

Forage Seed Production and Distribution Approaches of ACDI/VOCA

Assefa Amaldegn
ACDI/VOCA, Feed Enhancement for Ethiopian Development (FEED) project, Addis Ababa, Ethiopia, aamaldegn@acdivoca.eth.org

Introduction

The natural pasture and grazing areas became shrinking drastically and soil fertility has been eroded due to manmade and natural hazards. Thus, this time the main animal feed source is becoming crop residues that are nutritionally very poor in nutrition and palatability. During drought, when there is inadequate feed resource, the animals are emaciated with the majority of the stock succumbing to death. To avoid extreme losses, the farmers sell their stock at low prices and hence their value goes down.

Realizing these facts, ACDI/VOCA has designed FEED project to minimize this rampant feed problem. Feed Enhancement for Ethiopian Development (FEED) is a two-year project funded by the United States Department of Agriculture (USDA). ACDI/VOCA (Agricultural Cooperative Development International/Volunteers in Overseas Cooperatives Assistance/ is the project implementing Agency. It is a non-profit international development organization that delivers technical and managerial assistance in agribusiness, financial services, enterprise development, community development, and food security in order to promote broad based economic growth and vibrant civil society. The overall objective of the project is to improve the income of smallholders by improving access to animal feeds through building the capacity of unions/cooperatives to commercially manufacture animal feed and by enhancing technical skill and capacity of livestock feeders to produce and manage animal feed and forages.

To achieve this objective, different activities are being carried out under the three major components of the project. These components are:

- Commercial feed manufacturing;
- Feedlot and dairy nutrition and feeding management; and
- Forage production and pasture improvement

From its basic objectives of the project, it indirectly addresses food security of smallholders and pastoralists of selected regions by improving their income with a focus on improving the productivity and efficiency of the livestock sector.
through implementation of feed enhancement activities. Under these three major components of the project, HIV/AIDS and gender mainstreaming are considered cross cutting issues in the activities of the project.

**Project Target and Beneficiaries**

The project is under implementation in six regions of Ethiopia, i.e. SNNP, Oromia, Amhara, Tigray, Somali and Addis Ababa. Livestock productions in these regions contribute to the rural livelihood base and family income. The project areas are characterized by mixed farming and known for their huge number of animal resource.

During the formulation and design stage of FEED project, a preliminary survey was conducted with the aim of identifying intervention areas, geographic locations, scope of activities and identifying potential beneficiary unions and cooperatives. The project beneficiaries are about 73,000 potential union/coop member farmers and more than 2,600 non-member farmers. Among these membership 30% would be female. These individual beneficiaries are very poor and their animals are inefficient.

**Project Activity Accomplishments**

**Commercial feed manufacturing**
The overall objectives of implementing activities under this component are to enhance the nutritional value, availability and efficient use of livestock feeds, including commercially manufactured animal feed, in the target areas by building capacities of beneficiaries through activities that include awareness creation workshops, trainings, technical assistance, experience sharing visits and development support using grant agreement. The development support includes provision of animal feed grinder, feed mixer and urea molasses block presser.

**Forage seed production and distribution approach**
First, close preliminary survey is conducted with the aim of identifying proper area, potential beneficiary unions, coops, and individual farmers. Then training of trainers (TOT) is given to regional, zonal, and woreda forage experts how to develop, manage, and feed forages. The trained experts in turn give hands on training to unions, coops leaders, and individual farmers. Different forage seeds are purchased from research institutes/centers, NGOs, commercial producers and farmers. Based on the grant agreement procedure the purchased seeds are distributed to the identified unions; the unions to coops and coops use some of the seeds for themselves and/or distribute to individual member farmers. According to the grant agreement, the same amount of seeds will be paid back in kind (follow seed revolving mechanism) after harvest.
**Achievements**
During the first 20 months of implementation, the FEED Project has distributed to farmers 14,100 kg of different seeds and 1,405,642 seedlings and elephant grass cuttings through a “revolving in-kind” supply/distribution system established through target unions.

Based on a recent internal interim project assessment conducted in Oromia, Tigray and Addis Ababa regions (52 randomly selected household beneficiaries, 40 cooperative/union leaders, 10 farm site visits), more than 80% of households have allocated land for growing improved forages, with an average of 600 m² each. Respondents report that forage production from this land is providing 8-75% of their annual livestock feed requirements. Approximately 80% of those surveyed were able to collect enough seed for their own sowing needs. Some were able to sell forage seed to generate additional income. Milk yield of cows owned by project participant has increased by 1.5-3.0 liters per cow per day with significant supplementation of cultivated forages and urea treated crop residues.

**Problems Encountered and Lesson Learnt**
During the course of implementation, FEED Project experience indicates more effort is needed. Improved forage seeds/seedlings are still frequently in short supply, difficult to get and expensive and seed quality regulatory body is not active. At the same time, commercial ventures have had difficulty addressing this unmet need. Seasonality of forage production and its impact on supply and prices also remains an impediment to maintenance of livestock productivity throughout the year.

In the case of forage management, communal grazing (uncontrolled grazing) hinders the forage development especially out of their back yards. Traditionally, animals graze in crop fields after math freely without control. So if there is improved forage plant in the field, it would be very difficult to protect from animals. Thus, farmers are reluctant to plant especially perennial forage plants out of their backyards.

**Recommendations**
- Workable forage development policy that supports privat practitioners and researchers, and range land management (communal grazing) needs to be formulated and training and awareness creation should be done aggressively;
• To secure continuous seed supply government and coops’ nursery sites should give priority for producing more valuable forages which are difficult to multiply by farmers;
• Seed revolving mechanism is one of the best practices to avail forage seeds among farmers, so unions and cooperatives should work seriously on collecting and redistributing the available seeds regularly;
• Moreover, it is advisable to link forage development strategy with water and soil conservation activities (special attention is given at the time of site, farmers, and species selection); and
• BoA, dairy / feedlot unions, and coops have to work together in harmony like they are doing for other farming activities.
Farmers Forage Seed Production in Arsi Zone

Hizikias Ketema, Emmanuelle GuerneBleich, Hassen Ali, Fikre Mulugeta and Ameha Sebsibe

FAO-Sub Regional Office for Eastern Africa, Addis Ababa, Ethiopia

Introduction

Ethiopia has the largest livestock population in Africa and untapped livestock resource potential; however, performance in the production of the major food commodities of livestock origin has been poor compared with other African countries. As a result the role of livestock to the national economy as compared to the potential is low. Unavailability of feed in quantity and quality is one of the main problems that needs a priority attention among the existing constraints that contributes to the low production level and productivity of the livestock. Livestock is in shortage of feed supply and as the result the livestock is unable to give the expected production. To improve the livestock production and productivity, it is important to assure the availability of feed in quality and quantity throughout the year. In order to guarantee a sustainable supply of feed in quality and quantity, it demands forage improvement work using different forage development strategies. The different forage development strategies also require a range of various species of quality and sustainable supplies of forage seeds. To ensure this it is important to develop the local seed production potential to create sustainable and reliable supplies of forage seeds at affordable price to the livestock farmers.

Hence, the objectives of the study were to assess the situation of forage seed production at farmers’ level, to identify the existing gaps and problems related to forage seed production and to recommend possible solutions that strengthen the capacity of farmers to improve forage seed production and marketing.

Methodology

The study was undertaken in three Woredas of the Arsi Zone namely, Tiyo, Digelu Tijo and Lemu Bilbilo that have been practicing forage seed development since the beginning of the project. Arsi Zone is located 120 – 200 km from Addis Ababa (30-110 km from Adama). The area is composed of highlands with reliable bi-modal (Meher and Belg season) rainfall as well as drought- prone areas with many small-scale irrigation schemes. The area is located within the Awash, Rift Valley and Wabi Shebelle river basins.
In the study area a total of 140 farmers are engaged in forage seed production in the three Woredas. Of these a total of 43 farmers (11 farmers from Limu Bilbilo, 20 from Tiyo and 12 from Digelu Tijo were randomly selected and included in the study. Orientation was conducted for seven data collectors (agribusiness promoters and livestock experts at Woreda level). In addition to interviewing the farmers, focus group discussion were also held with farmers and experts from the Zone and Woredas. Moreover, in depth interviews were conducted to heads of Livestock Development, Health and Marketing offices at Zonal and Woreda levels.

Results and Discussion

Improved forage seed development activities in Arsi zone

The forage seed production was initiated in the 1970s by Arsi Rural Development Units (ARDU). The major forage-development and seed-production activity of the unit was supporting of dairying in Arsi. Key species included oats (*Avena sativa*), Vetch (*Vicia spp.*), Rhodes Grass (*Chloris gayana*), Phalaris, Panicum (*Panicum spp.*), Buffel Grass (*Cenchrus ciliaris*), Setaria, cocksfoot grass (*Dactylis glomerata*), Ryegrass (*Lolium perenne*), elephant grass (*Pennisetum purpureum*), green leaf Desmodium and fodder beet (*Beta vulgaris*). There has been good sustainability (with limited injection of new genetic material), with many farmers actively growing the original species *(LDMPS, 2007)*. Following this a number of projects were working on integrated forage and forage seed production including the Fourth Livestock Development Project (FLDP) *(Alemayehu Mengistu, 1996)*. The FLDP has imported different types of seeds with more emphasis on herbaceous and tree legumes. In the following years seeds were multiplied and collected in ranches, on specialized plots, from forage development sites and through farmers’ contract seed production *(Alemayehu Mengistu, 1996)*. All these systems served their purpose properly during the project life time. But, after the project phased out farmers seed production system has still been operational, though it is not as strong as it was during the project period. Now, few private commercial forage seed producers are emerged following the growing demand for forage seeds.

The forage seed production and forage development by farmers in the FAO-Crop Diversification and Marketing Development project area (Tiyo, Digelu Tijo and Lemu Bilbilo districts) was initiated in 2006 with the support of FAO and Land O’Lakes. The main forage seeds and seedlings that were being produced by farmers are fodder beet, alfalfa, tagasaste (tree lucerne), sesbania, oats, vetch, buffalo grass and elephant grass. Apart from the farmers, the government owned nurseries are also producing seedlings of tree lucerne and sesbania for soil and water conservation purpose as well as elephant grass seedlings to distribute to the farmers for forage development. The farmers
produce forage seeds either at their backyards or on their crop fields depending on the type of forages. Oats and vetches are commonly cultivated on crop lands. Even if the production of forage seeds by the farmers is mostly for own utilization at farm level, their involvement in the forage seed production has substantially contributed to forage development in the Arsi zone.

**Landholding and land use pattern**

The type of forage seeds that the farmers plant on their farmland are fodder oats and vetch. In the backyard the farmers mainly plant fodder beet, alfalfa, elephant grass, buffalo grass, tree Lucerne and sesbania. In this study, data was collected on the size of total land holding and the size of crop land, grazing land and backyard forage. As it is indicated in Table 1, the size of land holding owned by respondent varies among Woredas and farmers. The average land size allocated for crop production in both Lemu Bilbilo and Digelu Tijo is 3.0 ha, whereas in Tiyo it is only 1.4 ha (Table 1).

As it is observed from the focus group discussion, the farmers normally grow annual forage crops during both meher and belg seasons in all the three Woredas. The mean farm land size used for cultivating forage is only 0.1 ha in both Lemu Bilbilo and Tiyo, and 0.4 ha in Digelu Tijo Woreda (Table 1). The overwhelming majority of the respondents (92%) in Digelu Tijo and 60% and 63.7% respondents in Tiyo and Lemu Bilbilo, respectively, are using their farm land to cultivate annual forage, mainly for oats (Table 1). In Tiyo and Lemu Bilbilo, all the farmers those who plant forage seeds on crop lands use 0.5 ha or smaller land, while in Digelu Tijo 25% of the respondents use one ha or above.

Allocation of land for backyard forage is highest (0.4ha) in Digelu Tijo followed by Lemu Bilbilo (0.3ha) and Tiyo wereda (0.2ha) (Table 1). The majority of the respondents (80% and above) also use backyard to plant forage in all the three Woredas. About 70% of Tiyo, 41.6% in Digelu Tijo and 54.6% in Lemu Bilbilo respondents planted forage on 0.25 ha or less land at the backyard. The data also indicate that the respondents in Digelu Tijo use larger backyard for planting forage compared to the other two Woredas. The forage planted both in the farm land and backyard mostly (75%) used as a green feed and for hay making and about less than 25 % for forage seed production.

Although there is a significant variation in the size of grazing land among Woredas, almost all the respondents have their own grazing land. Fifty five percent of respondents in Tiyo and 41.7% in Digelu Tijo have 0.5 ha or less for grazing land, while the respondents in Lemu Bilbilo have larger mean land size (4.3 ha) for grazing land, over 80% of the respondents have more than one ha of land for grazing. The mean land size allocated for grazing land in Digelu Tijo and Tiyo wereda are 1.8 ha and 0.7ha respectively.
Improved forage/fodder seed production

Farmers use most of the forage they planted for animal feed at green stage. They keep only some of it for seed production. Hence, the forage seed production level is not directly related to the size of land used to grow forage. The average oats and vetch seed production is presented in Table 2. Average production of oats seed in Lemu Bilbilo is higher compared to the production of the other two Woredas and it increased from 7.4 q in 2008 to 8.5 q in 2010. The production of vetch has similar pattern, increased from 13 q in 2008 to 15.3 q in 2010 (Table 2).

Table 1. Land holding and land allocation for food and fodder crops production in the three Woredas of Arsi zone, Ethiopia in 2010

<table>
<thead>
<tr>
<th>Category /landholding (ha)</th>
<th>Tiyo (N=20)</th>
<th>Digelu Tijo (N=12)</th>
<th>Lemu Bilbilo (N=11)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Crop Land</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤1</td>
<td>50</td>
<td>8.3</td>
<td>18.2</td>
</tr>
<tr>
<td>&gt;1 and ≤2</td>
<td>40</td>
<td>33.3</td>
<td>18.2</td>
</tr>
<tr>
<td>&gt;2 and ≤5</td>
<td>10</td>
<td>50</td>
<td>63.6</td>
</tr>
<tr>
<td>&gt;5</td>
<td>0</td>
<td>8.3</td>
<td>0</td>
</tr>
<tr>
<td>Cultivated Land for forage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>40</td>
<td>8.3</td>
<td>36.4</td>
</tr>
<tr>
<td>0.1</td>
<td>15</td>
<td>8.3</td>
<td>0</td>
</tr>
<tr>
<td>0.125</td>
<td>40</td>
<td>16.7</td>
<td>27.3</td>
</tr>
<tr>
<td>0.25</td>
<td>0</td>
<td>33.3</td>
<td>27.3</td>
</tr>
<tr>
<td>&gt; 0.5</td>
<td>5</td>
<td>33.3</td>
<td>9.1</td>
</tr>
<tr>
<td>Backyard for Forage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>20</td>
<td>16.7</td>
<td>18.2</td>
</tr>
<tr>
<td>0.1</td>
<td>35</td>
<td>8.3</td>
<td>18.2</td>
</tr>
<tr>
<td>0.125</td>
<td>20</td>
<td>25</td>
<td>9.1</td>
</tr>
<tr>
<td>0.25</td>
<td>15</td>
<td>8.3</td>
<td>27.3</td>
</tr>
<tr>
<td>0.375</td>
<td>0</td>
<td>8.3</td>
<td>18.2</td>
</tr>
<tr>
<td>&gt; 0.5 and ≤1.75</td>
<td>10</td>
<td>33.3</td>
<td>9.1</td>
</tr>
<tr>
<td>Grazing Land</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤0.5</td>
<td>55</td>
<td>41.7</td>
<td>9.1</td>
</tr>
<tr>
<td>&gt;0.5 and ≤1</td>
<td>30</td>
<td>16.7</td>
<td>9.1</td>
</tr>
<tr>
<td>&gt;1 and ≤2</td>
<td>5</td>
<td>8.3</td>
<td>18.2</td>
</tr>
<tr>
<td>&gt;2 and ≤5</td>
<td>10</td>
<td>25</td>
<td>36.4</td>
</tr>
<tr>
<td>&gt;5</td>
<td>0</td>
<td>8.3</td>
<td>27.3</td>
</tr>
<tr>
<td>Homestead (ha)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 0.5</td>
<td>100</td>
<td>72.7</td>
<td>27.3</td>
</tr>
<tr>
<td>&gt;0.5 and ≤ 1</td>
<td>0</td>
<td></td>
<td>27.3</td>
</tr>
</tbody>
</table>

Table 2. Seed production of oats and vetch by participant farmers during 2008 – 2010 in three Woredas of Arsi zone.
 Bufallo and elephant grasses are the most popular grass species that are widely grown by farmers in the backyard. Among legume forage species alfalfa, tree lucerne and sesbania and fodder beet are widely used by the farmers in the backyard especially in Lemu Bilbilo Woreda (Table 3).

Table 3: Seed production of fodder beet and alfalfa by participant farmers in their backyards during 2008 – 2010

<table>
<thead>
<tr>
<th>Woreda</th>
<th>Oat (q)</th>
<th>Vetch (q)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2008</td>
<td>2009</td>
</tr>
<tr>
<td>Lemu Bilbilo</td>
<td>7.4</td>
<td>8.3</td>
</tr>
<tr>
<td>Tiyo</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Digelu Tijo</td>
<td>4.4</td>
<td>4.0</td>
</tr>
<tr>
<td>Total</td>
<td>13.3</td>
<td>13.3</td>
</tr>
</tbody>
</table>

Informal forage/fodder seed supply and seed source
The respondents indicated that seeds of oats, vetch, fodder beet and alfalfa primarily used for own use for their next planting season and to expand their backyard forage development. They sell the remaining seeds to other farmers. But, in the case of the other type of forage seeds and seedlings such as the tree legumes and the grass species they give to other farmers freely.

According to the respondents there are four different sources of forage seeds for farmers; the Zone and Woreda Livestock Development, Health and Marketing offices (LDHMO), different non-governmental organizations, farmers and Kulumsa Research Center. The LDHMOs are the major source of forage seeds to the farmers. Some of the Woredas LDHMOs have their own forage seed production nurseries and they produce fodder beet and alfalfa seeds. The nurseries distribute the forage seeds they produced to the farmers at market cost. Apart from this, the Woreda offices support the farmers who produced the forage seeds by selling their seeds to other farmers and organizations.

In Tiyo and Digelu Tijo LDHMO is the major source of forage seeds. But in the case of Lemu Bilbilo LDHMO and farmers are the major sources of forage seeds.
to the farmers (Table 4). In Tiyo, the farmers access forage seeds from all four sources (LDHMO, NGO, farmers and Kulumsa Research Center). The data also reveals that both farmers and NGOs have significant role in making forage seed accessible to the farmers. Almost all respondents said that they do not have any form of organization that is related with seed production.

Table 4  Source of forage seed in the three Woredas (% of respondents)

<table>
<thead>
<tr>
<th>Woreda</th>
<th>Source of Forage Seed</th>
<th>LDHMO</th>
<th>NGO</th>
<th>Farmers</th>
<th>Kulumsa Research Centre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Lemu Bilbilo</td>
<td></td>
<td>41.7</td>
<td>58.3</td>
<td>16.7</td>
<td>83.3</td>
</tr>
<tr>
<td>Tiyo</td>
<td></td>
<td>75</td>
<td>25</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Digelu Tijo</td>
<td></td>
<td>90.9</td>
<td>9.1</td>
<td>36.4</td>
<td>63.6</td>
</tr>
</tbody>
</table>

LDHMO-Livestock Development, Health and Marketing offices

Constraints

As it is observed from the focus group discussion and in-depth interview, the major challenges in farmers forage seed production are the lack of forage seed producers groups or cooperatives, lack of market and appropriate infrastructures, shortage of quality forage seeds and limited training opportunities. Organized cooperatives could have support the farmers by providing inputs that required for forage seed production, building their capacity and creating market opportunities.

Conclusions and Recommendations

The role of smallholder farmers in forage seed production is high and this will continue as it is for a long period. The private sector participation is increasing in forage seed production, though currently their role is insignificant in fulfilling the demand for forage seeds of the country.

The farmers are producing forage seeds at subsistence level because of limited market opportunity, they mainly producing forge seed to satisfy their own demand but not for selling. But, still in the three Woredas the farmers are one of the major sources of forage seed. As it is discussed with the zonal Livestock Development, Health and Marketing office head the respective offices at Woreda level are supporting the forage seed producer farmers by collecting the seed at Woreda offices and finding market within Woreda and out of the Woreda. But, the problem here is there is no any formal procedure to carry out this activity, just it depends on trust and there is no store for the seeds. These situations are creating burden to the farmers as well as to the producers.
Therefore, if the concerned body organizes the farmers in cooperatives the forage seed producer farmers will be able to address the challenges indicated above.

The other issue which needs more attention is the supply of basic and pre-basic forage seed to the smallholder farmers. During the focus group discussion and in depth interviews the sustainability of supply of basic and pre basic forage seed was raised as one the major issues that needs to be addressed. The research centers are the main source of basic and pre basic forage seeds. Therefore, the zonal LDHM office has to work closely with Kulumsa Research Center to alleviate the shortage of basic and pre basic forage seeds supply.

To strengthen the forage seed production and to produce quality forage seeds it is necessary to build up capacity of the professionals and the producers in forage seed production. Therefore, continuous training of trainers to zonal and Woredas professionals are required.

All the participants of focus group discussion and interviews stressed the need to link the farmers to various markets so that they can sell their seed. Following the increasing demand of forage seeds some private sectors are emerging and it is important to promote them and establish a good market linkage with such kind of companies. Private sectors cannot produce all types forage seeds for various reasons, but they can work with farmers through providing information, capacity building, technology transfer etc. to improve the availability and variety of forage seeds.

**Lessons learnt**

- Though no economic analysis conducted, as to the response of the farmers, very expensive forage seeds such as alfalfa, fodder beet etc. can be successfully produced with relatively low cost by smallholder farmers;
- Smallholder seed producer farmers do not have any form of organization that facilitate inputs and market accesses. Therefore, it is important to organize them in seed producers groups/cooperatives;
- The extension support that is given to the smallholder forage seed producers is not adequate. Therefore, it is necessary to support the producers by providing appropriate support through extension service;
- The Woreda experts and the forage seed producer farmers do not have adequate forage seed production knowledge. Hence it is important to support with various forage seed production trainings; and
- There is no linkage with other actors who are actively participating in forage seed production operations. Therefore, it is necessary to create linkages with actors who are participating in forage seed input delivery and marketing.
References


General Discussion and the Way Forward

General discussion

The general discussion has been conducted on three crucial agenda established by the participants. The three agenda were forage seed critical issues and priorities, production and supply systems, and policy and institutional issues. Discussions on the agenda were made by participants and issues raised, as well as ideas and suggestions forwarded are summarized hereunder.

Agenda One: Forage Seed Critical Issues and Priorities

- Forage technologies should be complete and need to have all the necessary information such as varietal information, agronomic recommendations, protection and post harvest handling;
- We should concentrate on our strengths and try to maximize on what we already have as has been already shown in the last two days of this workshop. The materials that do well and suitable areas to multiply the seeds can then be identified and used. Working together to learn from our collective experiences and develop collective strategies is necessary to improve the sector and enhance its contribution to livestock production;
- In variety development program, the local or indigenous resources should be considered and given priority instead of dwelling only on exotic materials;
- Socio-economists need to be brought on board to carryout precise assessments on the social and economical issues surrounding the forage seed production and supply systems;
- Most forage researches were done in the central highlands of Ethiopia. Evaluation of forage materials were not equally done in other agro-ecologies. Therefore, designing multi-location forage evaluation strategy is necessary so that potential areas for seed and herbage yield can be identified, and to widen the scope of work in the area. Therefore, widening the scale of forage development research endeavours across the regions and agro-ecologies is required;
- Participatory research approach needs to be strengthened for appropriate and adoptable technology development in the area;
- There is a need to establish facilities to conduct supportive research, for instance in biotechnology (clonal propagation of sterile species), rhizobiology (development of inoculum following variety development of various legume species), etc;
- Trained personnel to conduct forage seed research is an obvious constraint. Therefore, there must be capacity building in terms of forage seed specialist training in the short, medium and long term; and
- Seed production is normally precedes variety development and the procedure of variety development must be standardized at a national level.
Agenda two: Production and Supply Systems

- To strengthen the seed system, establishment of a system is required and policy makers and other stakeholder should be aware of that. This would give emphasis to understand the importance of the forage seed sector;
- The gap is knowledge. Therefore, packaging the available knowledge in a way that is easy and understandable is necessary. As such information should be available in local languages for farmers;
- Issues in forage seed production and supply should look into the identification of important forage varieties, basic and pre-basic seed production by research centers, emphasis by Ethiopian Seed Enterprise (ESE) for important forage seed multiplication and distribution, encouraging informal seed system (farmers, cooperatives), and targeting farmers producing high value livestock commodities;
- There is a serious problem of basic seed supply in the country, only EIAR and ILRI supply small amounts of forage seeds. Awareness is a problem and extension works should be done to promote forage technologies to encourage forage seed production;
- The basic seed supply is a critical issue that needs to be discussed and clarified. Everybody claims there are no basic seeds available but it is not clear who should take care of it. This is a missing link that is a bottleneck. ILRI have requests every year, requesting materials that we already distributed to the same users many times before;
- Production and supply schemes for forage seeds are critical issues that need responsible body. Agricultural extension should promote adaptable materials and organize producers at each agro-ecology; research institutes should produce sufficient amount of basic and pre-basic seeds; and ESE should involve in forage seed production regardless of the profitability issue;
- The informal seed system is the one that should be our strategy since the formal sector has no immediate future in the absence of real demand from the actual forage producers. The role of government institutions would then be to organize seed producers and link them with animal producers. The forage and pasture program must be represented in the standing committee of the national variety release team;
- The seed system in Ethiopia is weak, particularly forage crops seed production. It is difficult to lure private seed producers at significant number to produce forage seeds. For the foreseeable future efforts must be made to strengthen the informal seed sector. There are success stories in this regard. For example panicum seed production in Afar and haricot bean seed production in the rift valley. Large number of agro-pastoralists and farmers joining in because they gained benefits;
- Seeds should be produced in selected areas by few and trained farmers. As such potential areas must be identified in major agro-ecologies;
- To improve forage seed production and supply system, problems associated with new variety registration and the production of breeder, pre-basic and basic seeds should be solved. Research centres are not operating at full capacity and need to be supported adequately to effectively do the job;
- On the issue of forage germplasm supply, researchers are not being assisted by IBCR in the same way as the crop sector is enjoying. Therefore, IBCR should
function to assemble commercial and experimental materials in forages and make it available to breeders;

- Many materials identified and demanded are not yet registered as a variety. This must be done. Moreover, seed producers must get incentives from organizations as seed production on small scale is not profitable;

- Basic seed supply is the task of breeding institutions or centres. Moreover, identifying and setting the priorities in terms of the species, registering varieties, setting seed production systems, working on extension and popularization activities, coordinating the stakeholders and identifying their role and link them properly are issues that need to be addressed;

- The national seed authority should have components that handle forage seed. The seed authority should regulate activities of the informal and formal seed production. Farmers producing seeds in the informal sector should be organised. The research and extension groups should organise farmers into associations even to highly formal ones with constitutions and even should do registration. The authority should regulate quality and price to prevent the collapse of the system due to serious imbalances;

- More than 2500 FTC/PTCs are found in the country and they only involve in demonstration of biomass production. But they can also produce seeds and be a good source of seed which improve seed distribution; and

- The information on the alternative use of root split for enhancing propagation of napier grass in cools areas was not commonly discussed and yet it is very useful information for the region and should be shared widely. Lower number of splits that can be obtained may possibly limit germplasm distribution and scale-up programmes.

### Agenda three: Policy and Institutional Issues

- National seed industry policy is comprehensive and appropriate. But variety release mechanisms need revisiting. For forage research and seed producers, ESE had little experience and seed standards should be set;

- There should be a quality regulatory or control body to ensure quality seed supply.

- Organizational structure is very important and emphasis should be given to the livestock sector and particularly for feed development;

- Institutional issues and policies that often inhibit or do not favour working together within and across institutions should be revised. There is often willingness of people to work together and collaborate. But that may not be effective due to institutional issues. A good examples with room for improvement if collaboration is increased is standardization of the research procedures and sharing of information for instance about forage varieties released. The parameters evaluated and type of data collected varies depending on the research. For examples, some evaluated nutrient, while others did not. Generally one could benefit a lot if information is shared;

- There should be a multidisciplinary team that should do as part of the terms of reference, review of the seed policy to identify any areas that may present challenges to smooth implementation of the forage seed processes. Focus should not only be on seed certification;
• There are a lot of information on similar forage species for similar and different agro-ecological regions of the country. It is very good that this workshop has been held because now all this information discussed can be consolidated for effective use, to establish proven issues and not to spend research resources on such issues and rather identify gaps on which to utilize research resources. The information discussed can also be a basis to set appropriate future policy directions and institutional issues;

• Seed regulatory board with ESE and Ethiopian standard, need for drought resistance species to mitigate climate change. Conversely, it is better to give due attention to regional seed agencies as possible forage seed producer rather than depending much on ESE;

• Weak institutional linkage among institutions involved in forage development (MOA, EIAR, IBC, ILRI, etc) in the country is one of the major problems contributing for stagnation of forage technologies. Institute of Biodiversity and Conservation (IBC) is not fulfilling the demand of forage seeds required by customers. This is related to major priority given to food crops. In the new reform, focus has been given to forage crops and we believe it will change the existing situation; and

• Emphasis should be placed on gender desegregated data, and development activity in forage seeds should give due attention to female headed households.

Way Forward to Improve Forage Seed Production and Supply System in Ethiopia

On the last date of the workshop critical discussion were made on three basic topics: forage seed critical issues and priorities; forage seed production and supply system and policy and institutional issues. In this discussion, important points were raised on major issues that need emphasis to improve the image of overall forage seed production and supply system in the country. Major selective issues raised as way forward and discussed are briefly outlined below.

Forage Seed Critical Issues and Priorities

• Efforts should be made to concentrate on and benefit from what are already known and have been reported in this workshop. It is possible to identify which forage materials have done well, and the suitable areas to multiply the seeds. For this, working together and learning from collective experiences and developing collective strategies are pre-requisites;

• Forage technologies should be complete consisting of variety information, agronomic recommendations, nutritional composition, protection and post harvest handling. To realize this multidisciplinary team should involve in variety development studies including breeders, agronomists, pathologists, entomologists, socio-economists, etc. Moreover, collaborative research from biotechnology for clonal propagation of sterile species and Rhizobiology for development of effective inoculum following forage legumes variety development should be started to generate robust technology that benefit producers; and
• Forage seed research has not been given due attention for the last two-three decades since the commencement formal forage development studies in Ethiopia. Efforts should be made to strengthen this aspect at a national level and capacity building with regard to forage seed specialist through training at least in medium and long term programs must be organized to bring a remarkable progress.

Production and Supply System

• Generally the seed system in Ethiopia was blamed to be very weak, particularly that of forage crops which is one of the bottleneck for feed and livestock development endeavours. Lack of forage seed production component in the national seed enterprise made the problem to persist over decades. As the way out, it was strongly recommended that national seed enterprise should consider forage seed production at large and regulate the activities of informal and formal productions with respect to seed quality and price;

• The informal seed system was taken as a foreseeable and practical strategy since the formal sector has no immediate future in the absence of real demand from the actual forage producers. The role of government institutes (extension and research) should then be to identify highly demanded forage species, potential areas for their seed production, train and organize seed producers into associations even to highly formal ones with constitutions and registration, and link them with animal producers;

• Active involvement of Farmers Training Centers (FTCs) available in the country (>2500) in seed production and as a forage gene bank was also considered as a potential intervention option that improve seed supply and distribution in the country;

• Basic and pre-basic seeds production and supply was also identified as a serious problem in the country. Only few institutions (EIAR, RRIIs and ILRI) were involved in seed production and their supply was very limited. It has been reached in agreement that basic seed supply is the task of breeding institutes. Moreover, identifying and setting the priorities in terms of the species, setting seed production system, working on extension and popularization activities and coordinating the stakeholders, identifying their role and linking them properly are the issues that need to be addressed;

• Variety registration was considered as one of the national research gaps. Although some efforts has been made and started, the team reached to a consensus that the release mechanism should be standardized and forage and pasture crops researcher should be included in the national release committee; and

• Knowledge was identified as a gap that needs to be addressed. Available knowledge should be organised as packages in easy to understand ways using local language for farmers.
Policy and Institutional Issues

- Weak linkage among institutions involved in forage development (MOA, EIAR, IBC, ILRI, etc) in the country was identified as a major problem contributing for the stagnation of forage technologies. There must be institutional issues and policies that favour team working and sharing information which benefit stakeholders at all level;
- There should be a quality regulatory or control body to ensure quality seed supply; and
- Research outcomes, information and knowledge should be consolidated periodically like this workshop in which proven issues are established and helps to avoid effort duplication and rather identify gaps on which to utilize resources to address the prevailing feed shortage in the country.
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