P-ISSN: 2305-6622; E-ISSN: 2306-3599
International Journal of
Agriculture and Biosciences
www.ijagbio.com; editor@ijagbio.com

Review Article

Overview of Improved Forage and Forage Seed Production in Ethiopia: Lessons from Fourth Livestock Development Project

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

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

Article History: Received: September 12, 2017 Revised: December 06, 2017 Accepted: December 18, 2017

ABSTRACT

This paper summarizes the forage production program of the fourth livestock development project implemented in Ethiopia. Various promising improved forage production strategies were developed and successfully implemented in project areas. The strategies were evolved from experiences of other countries and an understanding of the importance of matching forage systems to different agro-ecological zones of the country. Moreover, the project involved in producing forage seed under contractual basis with individual farmers and cooperatives to enable the production of larger amount of seed per unit area with lower cost of production. Generation of different forage seed production technologies which are feasible for different agro-ecologies are extremely important for better quality forage and forage seed production but the technologies are not yet well demonstrated for most forage species. Therefore, identification of suitable sites, land preparation, seeding rate, sowing date, sowing methods, weeding management, fertilizer rate, forage and seed harvesting stages and others agronomic managements were considered for successful establishment and productivity of each introduced forage species. So, the project demonstrated different promising and high yielding forage species with recommended production packages for large number of farmers in different regions and the project farmers were well acquainted and successfully produced forage and forage seeds of the introduced improved forage species. Improved forage production program must be adapted to the economic, social and environmental conditions of each intervention region. Due to this, some fundamental requirements were included in the program for successful implementation of forage and forage seed production. Active farmer participation at all stages of production, strong institutional support, a planning approach to implementation, motivated technicians located throughout the project area to extend forage strategies and conduct adaptive research, initial importation of improved forage seed, financial mechanisms to enable contract seed growing, secure land tenure for farmers and monitoring and evaluation were some of the major requirements considered for successful implementation of the project. Generally, the project was the first of its kind in Ethiopia in implementing extensive forage development interventions which are specifically suitable to the smallholder mixed crop-livestock farmers and generated valuable lessons for similar livestock development programs in the country.

Key words: Development Project, Forage Conservation, Forage Seed, Production Requirement

INTRODUCTION

Livestock production is one of the major components of agriculture in Ethiopia. It is an important component of nearly all farming systems in Ethiopia and it provide milk, meat, draught power, transport, manure, hides, skins (Funk *et al.*, 2012) and it serves as a source of income. The livestock sector contributes about 15-17% of the total gross domestic product and 35-49% of the total agricultural gross domestic product (ATA, 2012). This is rather low considering the rapidly increasing human population and increasing demand for meat, milk and draught power. Currently, productivity per animal is very low and the contribution of the livestock sector to the overall economy is much lower than expected. Despite enormous contribution of livestock to the livelihood of farmers, they are faced with multifaceted problems in the production system, among which the major one is the

Cite This Article as: Mengistu A, G Kebede, G Assefa and F Feyissa, 2017. Overview of improved forage and forage seed production in Ethiopia: lessons from fourth livestock development project. Inter J Agri Biosci, 6(4): 217-226. www.ijagbio.com

quantitative and qualitative inadequacy of feed supply (Manaye *et al*., 2009). Indeed, insufficient and poor quality feed, particularly during the dry periods was reported to be one of the most important constraints to the Ethiopian livestock feeding systems (Anderson, 1987). Similar studies reported feed resources to be the major bottleneck to livestock production in the highlands of Ethiopia, where natural pastures and crop residues are the major sources of feed (Seyoum and Zinash, 1995; Zinash *et al*., 1995).

The main feed resources for livestock are natural pasture and crop residues, which are low in quantity and quality for sustainable animal production (Tessema *et al*., 2002; Tessema and Baars, 2004). Alemayehu (2004) also noted that more than 90% of the livestock feed is contributed by crop residues and natural pasture, this results in low growth rates, poor fertility and high mortality rates of ruminant animal (Odongo *et al.*, 2002; Shem *et al*., 2003). The livestock feed resources generally affected by poor quality and quantity (Tolera and Abebe, 2007), drought (Alemayehu, 1998b), ecological deterioration (Alemayehu, 1998a), overgrazing, land tenure (CSA, 2008), weed and bush encroachment (Biqila *et al*., 2014, Gemedo, 2006), soil infertility (Alemayehu, 2006) and lack of planting material. The production of forage to overcome dry season livestock feed shortages is dependent on the availability of reliable supplies of quality seed at the time of planting. Thus, in order to solve the shortage of feed and increase livestock productivity, it is necessary to promote and cultivate high-quality forages with high yielding ability and adaptability to the biotic and abiotic environmental stresses (Tessema and Halima, 1998).

Forage development programs need to include local seed production to ensure their long-term sustainability and economic viability. Because of the wide range of agro-ecological zones (AEZs) and farming systems in Ethiopia, many species are required, but local production of seed for key species can be initiated very early to meet the forage seed needs of a forage development program. Past research has identified a range of adapted and productive forages that can be integrated in the local production systems for improved livestock productivity. Despite assembling of these species of forages, adoption by livestock farmers is low. The biggest challenge is accessibility of seed and knowledge and capacity on how to multiply the seed and improve availability to farmers. The formal forage seed system is not well developed compared with seed systems for food crops in the country. There is limited involvement of private sector and as a result good quality seed is expensive and beyond reach of local livestock farmers. On the other hand, seed production methodology of these forages have not been developed or defined across the regions. Consequently, there is need to develop management practices for different forage species to define techniques for optimal forage and seed production. Therefore, this study reviews the forage production program of the fourth livestock development project implemented in Ethiopia.

The fourth livestock development project

Different livestock development projects launched in Ethiopia during different periods to avail promising technologies that help to overcome the feed shortage problem so as to improve livestock productivity. Among the various projects, the Fourth Livestock Development Project (FLDP) has made substantial contribution to forage development via introduction, multiplication and promotion of promising forage species to smallholder farming systems (Fekede *et al*., 2015). The FLDP had demonstrated a series of alternative strategies in improved forage production over large parts of Ethiopian highlands. The FLDP was the first of its kind in Ethiopia in implementing extensive forage development interventions specifically to the smallholder mixed crop-livestock farmers of the highlands, and by doing so, it generated valuable lessons for similar livestock development programs. The improved forage production strategies developed and successfully implemented by the FLDP in Ethiopia evolved from experiences in other countries and an understanding of the importance of matching forage systems to AEZs. The strategies are farmer centred and were developed with farmers to maximize sustainable income generation and food production at the household level. The key forage production strategies are conservation based and promote the use of legumes as improved forage (Alemayehu, 1989; Robertson, 1990). Some of the major strategies are summarized in Table 1. Moreover, the project involved producing seed under contract with individual farmers and cooperatives to enable 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 (Alemayehu and Getnet, 2012). Based on this contract, the project provided the initial seed at planting including the necessary technical advice and supervision and farmers were obliged to follow the technical advice on forage seed production 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 tones, contributing substantially to reduced importation (Alemayehu and Getnet, 2012).

Importation of initial seed

The first years of an improved forage production program will normally need to be established with imported seed. The cost of seed is small compared to the benefits of rapid and widespread implementation of improved forage production. Small quantities of a very wide range of species and cultivars should be imported along with larger quantities of proven species or cultivars to initiate forage programs. Regional trials should be conducted with untried species and cultivars to assess their suitability for wider use. Wherever possible these trials should be conducted in farmers' fields but careful planning and supervision of the trials are important to protect them from grazing and to ensure the small quantities of seed are effectively used. Australia is the largest producer of tropical forage seeds and has a well-organized and competitive seed exporting industry. Imported seed should be certified true to type and of minimum purity, and be tested for germination prior to

shipment. Imported seed should be supplied in sealed, weatherproof sacks or small cloth bags with printed labels on each sack or bag identifying the species, cultivar, source, date of harvest, and recommended storage conditions. Seed treatments are not normally required for forage seed but inoculants and gum adhesives should be included for leguminous species, which are not naturalized in the forage production area. Importation of forage and browse seed should not be necessary after the start-up phase of a forage program typically three years. Self-sufficiency in major forage species and cultivars requires a planned seed production program which is farmer based and market oriented. The basic objective of a successful forage seed production program should be low cost seed production by farmers based on contracts, which do not compete with subsistence food production. This approach has proved successful in Ethiopia where forage seed production is now treated as a cash crop by smallholder farmers.

Contract seed production

The most successful method of producing forage and browse seeds in Ethiopia has been to contract farmers to grow or collect seed. Contract seed production involves establishing a contractual agreement between a farmer and the seed purchaser usually the Ministry of Agriculture, but sometimes a seed trader. The seed contract is a legally binding agreement between the purchaser and the farmer or a group of farmers. Both the purchaser and the producer must make certain commitments under the seed contract. Contract prices are based on estimated yield, production costs, the market for seed and the cost of imported seed. Local seed prices will normally be significantly less than imported seed prices because they exclude shipping or airfreight costs. As an example, contract seed prices paid to Ethiopian farmers for seed produced in 1990/91 were typically one third to one half of the import price. Contracts must be arranged well before the crop is grown and should detail: which species and cultivar is to be grown; who will supply the parent seed and when it will be delivered; technical supervision during planting, growing and harvesting; minimum quality standards for produced seed; and the price paid for a given quantity and quality of seed. Before contracting seed growers, the contracting agency (buyer) should conduct group meetings with farmers to ensure that they fully understand the technical and contractual aspects of seed production. Although it is desirable to spread the program over a wide range of geographical locations and AEZs, it is important to cluster production sites to facilitate supervision and seed collection. The area of land needed to produce the quantities of pasture seed required for most forage development schemes is very small compared to the total cropping land available. Observations on forage seed production on different production systems is indicated in Table 2. Thus pasture seed production will not compete with food production. Apart from contract seed production, farmers can also opportunistically collect seed from browse species and other species growing in stock exclusion areas, forage strips, and under sowing sites. Opportunistic seed collection can also be contracted.

Pre and postharvest conditions for forage seed production

Site selection: The most suitable regions for forage and browse seed production have: an adequate growing season to support good seed set and maturation; freedom from frost; even sunny conditions during flowering to promote flower opening, pollination and high rates of photosynthesis during seed differentiation; access to labor for harvesting and seed cleaning; and access to markets and seed storage infrastructure. Weed free areas or areas that have a history of reasonably clean cropping are preferable to weedy areas to minimize the problems of weed competition in the seed crop.

Table 1: Key Observations on Forage Strategies

Strategy	General Comments	Limiting Factors
Backyard Forage	Widespread adoption; useful point of entry for new species.	Many areas too small to have impact on production.
Undersowing	Widespread adoption with annuals; shifting towards being self-sustaining; some species now locally traded, and consumed as human food.	Continued government support slowing shift towards self-sustainability.
Oversowing	Success dependent on site selection; some excellent persistence/spread over ten years; better results below 2,400m Aerial seeding of 1988/99 successful on suitable sites, including for tree legume establishment.	Availability of perennial legume seed at very low cost. Suitable delivery systems for large inaccessible sites
Stock Exclusion Areas	Very successful for control of degradation and fodder production; excellent performance of introduced legumes in many sites; need to reinforce all with legumes; need to allow regular cutting from outset.	Availability of perennial legume seed at low cost; appropriate policy on utilization; local adoption of cut and carry management.
Intercropping	Some success with *Desmodium* under coffee and citrus, insufficient emphasis to date; need to concentrate on areas with livestock.	Some of the most suitable species not yet available in the field.
Hedgerows of Leguminous Trees	Some excellent results with *Leucaena*, *Sesbania*, tree lucerne; but scale often too small. Need to expand to include crop areas, and to link to intensive utilization for fattening and dairying. Utilization good in only some systems, but improving in most areas.	Inadequate awareness of benefits, inadequate stock control in most farming systems; most *Leucaena* not inoculated.
Contour Forage Strips	Most destroyed with collapse of Producer Cooperatives; beginning to regain momentum in some areas; potentially very important and needs to be stressed; needs to be linked to intensive livestock enterprises.	Local availability of suitable grasses and companion legumes.

Source: Alemayehu M., 1989.

Table 2: Observations on forage seed production on government farms and smallholder contract schemes

Key Indicator	Government Farms	Smallholder Contract
Yield per area	Variable	High
Cost per unit of seed	High	Low
Predictability of annual production	Low	Very high
Reliability of supply	Variable	Very high once established
Capital investment required	Variable – high	Negligible
Organization required	Continually high	Initially high
Suitable species groups	Grasses	All annual and perennial legumes
Requirements for success	Continual funding, supervision, organization of labour	Technical supervision, reliable market, timely purchase

Source: Alemayehu M., 1989.

Table 3: Seed production characteristics for selected forage species

Species	Min % germination	Purity %	Seeds /kg '000	Sowing rate kg/ha	Seed yield kg/ha
Forage Legumes					
Alfalfa	60	95	400	15	200-600
Axillaris	60	95	120	3-5	150-500
Wynn Cassia	60	90	250	2-4	150-500
White Clover	60	90	1,500	2-3	100-400
Cow Pea	75	98	10	10-20	500-800
Greenleaf	60	90	750	3-4	100-400
Silver leaf	60	90	210	4-5	100-400
Siratro	60	95	75	3-5	200-950
Seca Stylo	40	90	425	5-10	200-750
Verano Stylo	40	90	400	5	150-750
Cook Stylo	40	90	300	5	300
Maku Lotus	60	90	2,200	1	100-400
Vetch	75	98	14	15-20	700-2,500
Browse Legumes					
Leucaena	60	98	24	4	5-10
Pigeon Pea	60	98	20	5	1-5
Sesbania	60	95	100	3-4	5-10
Tree Lucerne	60	98	60	3-4	5-10

Source: FLDP, 1991 and O'Reilly, 1987.

Seedbed preparation: Seed crops need to be established in a clean, fine and firm seedbed with sufficient seed to ensure a strong, dense plant population, which will compete with weeds and maximize yields. Ethiopian experience suggests that the maximum size of a seed crop for smallholder farmers is about 0.25 ha (FLDP, 1991). Legumes seeds need to be treated to soften hard seeds, which will not germinate without treatment. Browse legumes and herbaceous legumes with less than 500,000 seeds per kg should be treated. The simplest say is to boil water in a tin, remove the tin of boiling water from the fire, and immerse a cloth bag containing the seed in the hot water for about 10 minutes. The treated seed should then be rapidly cooled by spreading it out in a thin layer. Stylos are sensitive to heat so they should only be immersed for 3 minutes. Where hot water treatment of seed is impractical, scarification is suitable alternative. The simplest way to scarify or scratch the seed coat is to combine some seeds with sand or gravel and thoroughly mix them together so that the gravel or sand scratches the seed. This will normally take at least 15 minutes.

Sowing: When using cultivars or species new to an area, legume seed should be inoculated with appropriate rhizobia to ensure that they fix nitrogen. Seed should be sown as soon as possible after the beginning of the main rainy season. This reduces the risks of crop failure. Small forage seeds (more than 20,000 seeds/kg) are broadcast onto the seedbed and raked in. Larger seeds are either sown in rows or buried, with a light cultivation, no more than 3 cm deep after broadcasting. Sowing in rows reduces the quantity of seed required and makes weed management and harvesting simpler. Row spacing should be 50 cm for small seeded forage legumes, vetch, stylo, desmodium, and grasses. 1 m row spacing should be used for siratro, axillaris, and cowpea. Browse legumes being grown for seed should be planted in rows 3 m apart. Sprawling legumes such as axillaris, desmodium, and siratro produce much higher seed yields if seed crops are grown on trellises, browse trees, or along fence lines. Seed production characteristics are suggested in Table 3. Some plants reproduce without seed from sets or cuttings. Several grasses are more effectively reproduced this way for example hybrid phalaris and these may be grown by farmers and sold on a contract basis of so much per rooted cutting or set.

Management: The overall aim of seed crop management is to consistently succeed in producing a seed crop with not only a high yield of quality seed, but also a crop, which allows efficient seed harvesting. This essentially means having a crop of uniform age and is best achieved by: establishing an adequate, uniform plant population; developing a dense cover to exclude weeds, encouraging flowering at the same time; and ensuring that flowers produce mature seeds. Regular crop inspections are important to control weed and pest populations. Weeds should be hoed or pulled by hand. Weeds not only

compete with the seed crop but they also increase the risks of contaminating forage seed with weed seed something which increases the work required for effective seed cleaning. Advice on pest management should be sought from local Plant Protection Specialists or Extension Advisers.

Harvesting: Most tropical legumes flower and set seed over a long period and frequently shed seed quickly. This makes it very difficult to judge when to harvest seed. Techniques used to judge ripeness include testing for ease of seed removal; seed hardness; and field colour. When most seed can be easily removed by gentle rubbing or shaking, then seed is normally close to shedding and should be harvested. If seed rubbed in the palm of the hand is hard and dry then it is mature and ready to harvest. Grass seed should be bitten to ensure that is full. The seed or pods of some species, for example siratro, rhodes grass, tree lucerne and leucaena, change colour as they ripen. The optimum harvest time usually occurs before maximum flower density occurs. Hand harvesting of tropical pasture seed, particularly if labour is experienced and well supervised, can lead to high yields of good quality seed. Hand harvested yields are generally higher than yields from mechanical harvesting. As an alternative to hand picking, mature seed of both grasses and legumes can be removed from the plant by shaking it into a basket or bag. Hand picking and shaking two or three times per week will maximize seed yields and farmer income. Small seeds can be collected from threshing areas by sweeping. This technique is particularly suitable for stylos, wynn cassia, and axillaris.

Cleaning and drying: Legume seed should be dried as soon as possible after harvest to achieve a seed moisture content of 8 to 10 per cent. This ensures good seed viability. Seed can be sun dried without damage to the seed. Grass seeds should be heaped immediately harvest so that they will "sweat" to assist final maturation of the seed. Grass seed is more sensitive than legume seed and should be dried slowly to maintain its viability. Sun drying is not recommended because of this, grass seed can be dried in the shade. All drying seed should be turned regularly at least once per day to ensure efficient drying. Dried seed is then threshed using animals, a mortar and pestle, or beating with sticks or flails. Regular inspection of the seed is essential to avoid damage to the seed. Threshed seed is then cleaned to remove seeds of contaminant species, soil, chaff and poor seeds. Winnowing and sieving are the normal means of cleaning seed. Most farmers in Ethiopia are skilled at manual seed cleaning of both coarse and fine seed, for example maize and tef.

Storage and labelling: Once cleaned, harvested seed must be stored in a cool and dry place. The length of life of a seed in storage depends on the environment in the seed store. For storage beyond 5 years, seed should be kept at temperatures below 15^0C with relative humidity below 4%. An indication of seed store suitability can be calculated by adding the average temperature (^{0}C) and the average relative humidity (%) from the store. This is the storage index. For example, a seed store with an average temperature of 20^0C and average relative humidity of 45% has a storage index of 20 + 45 = 65. Short term storage (<6 months) requires a storage index of less than 80. Medium term storage (6-18 months) requires a storage index of less than 70 and long term storage (up to 5 years) requires a storage index of less than 50. Grass seeds should be stored in a sealed container but cotton sacks or woven bags are suitable for most legume seeds. Seed stores should be well ventilated, secure, and clean especially free from insects and rodents. Each seed container must be labelled with information on: the species; the cultivar; the date of harvest; the location of harvest; the weight of seed in the container; and any seed treatments (for example scarification or insecticide dressing).

Forage seed distribution

Distribution of seed must be planned in advance of the next cropping season. This is best achieved with an annual forage plan, which is developed by farmers and extension agents. This "bottom-up" participatory element is essential for successful extension and management of forage programs. The annual forage plan for the coming season will ideally have contributed to determining how much forage seed was contracted to be grown in the previous season. The coordination required for successful forage program planning requires time and skill and is best done on a regional or national level. This coordination requires an accurate knowledge of existing seed supplies so that any shortfalls can either be imported or taken into account by modifying the forage program for the coming season. Once regional forage program targets have been established, seed mixes and quantities are prepared for each administrative region. This may involve moving seed from one region to another to ensure that each region has sufficient seed to meet farmer demand or forage program targets. At the regional or local level, seed is split and, where necessary, mixed into seed packs for use by farmers. Seed packs typically have sufficient seed to establish a small nursery of browse species for backyard strategies, enough seed for under sowing 0.25 ha of crop, or enough seed to sow 250 m of contour forage strips. Strategies such as over sowing or improvement of stock exclusion areas for communal areas would have larger seed packs, which would be used by grazing management groups or pastoral associations. Forage programs are most successful where seed is inoculated and scarified at a regional level before being split into farmer seed packs. This helps ensure success during establishment. Seed packs should be clearly labeled and include sowing and early management instructions.

Forage conservation

Forage conservation helps to bridge the quantity gap between livestock feed requirements and the production of forage. If good quality forage is conserved, the nutritional gap between high quality (wet season) and low quality (dry season) forage may also be bridged. Hay produced from natural grasses, improved forage legumes and browse legumes is the most appropriate conserved forage for small-scale fattening or dairy production in Ethiopia. Forage conservation is especially important for dairy production because it ensures a supply of balanced

nutrients for dairy animals throughout their lactation. A mixture of grass and legume forage should be harvested for quality hay. The legumes increase the digestibility and intake of the conserved forage. If mixed grass-legume forage is not available for hay making dried legume forage can be mixed with grass hay in a dry matter ratio of about 1:2 to provide a balanced ration for ruminants. For high quality hay, forage should be cut just before grasses flower. This will produce good yields of hay with high digestibility and protein content. Although cutting hay after plants have flowered produces more hay, it is of lower quality than earlier cut hay. Quality hay is typically cut 4 to 6 weeks after the pasture or forage crop has been closed to grazing. Quality hay is cut before flowering of the grasses and ideally between rainy periods. Cut hay should be dried as quickly as possible and should be turned regularly during drying to keep the hay mould free. Once the hay is dry, it should be stacked using the "heap-up" methods. Haystacks should be constructed so that they are tall and thin with the smallest possible surface area at the top to increase their resistance to rain. Flat topped and broad haystacks are not weather proof so that the hay will be damaged by rain. When conserving crop residues such as straw, layers of leguminous forage or browse hay should be sandwiched between the layers of crop residue. This increases the feeding value of the crop residues and provides a balanced livestock diet. Alternatively, separate haystacks can be made from crop residues and forage and browse legumes.

Requirements for success of the project program

Farmer participation at all stages: Successful improved forage production programs involve farmers from the very beginning. By conducting diagnostic survey or problem census meetings during the identification and preparation phases of the program, it can be designed to solve key problems identified by farmers. This ensures high adoption rates and increases the likelihood of improved forage strategies developed for each region being appropriate to local circumstances. For example, farmers identifying fuel wood and shelter as priority problems are more likely to adopt strategies involving browse legumes than under sowing strategies. Similarly, a village or group of individuals, which collectively give priority to land degradation of common lands are more likely to organize themselves into grazing management groups or pastoral associations to implement over sowing and stock exclusion strategies than farmers who place priority on food security issues. Problem census and diagnostic survey techniques, especially where they are farmer led rather than technician pushed, provide a clear message about which strategies are likely to be most successful for each group farmers. Strategies which solve priority problems provide the most successful starting point for an improved forage production program which will gradually evolve to cover the whole spectrum of strategies - backyard forage, integration of forage and crop production, and enrichment of common lands.

Implementation of a program identified and prepared with farmers is much more simple than initiating a program that is completely new to them. Farmers must participate not only in the implementation of each strategy obviously on their own land and in their own backyards or compounds, but also on common land but they must also contribute to the planning and coordination of implementation. This builds up improved forage management skills, which will help ensure the program's sustainability at the end of the initiation phase. For example, farmers should be consulted about their forage seeding plans for the forthcoming season and helped to convert this information into anticipated seed requirements. This forms the basis of annual forage production plans discussed below. Monitoring information should be shared widely with participating farmers to help them feel that they are part of a wider effort and to give them technical information about the experiences of others which may be of use to them. Information sharing can be achieved through simple newsletters or village posters, or through regional demonstrations and meetings, which bring farmers together. The latter approach is more expensive and difficult where transport problems may exist. Farmers should be integrally involved with adaptive research, especially where it is conducted on-farm. In this way research ideas are constantly being validated by the ultimate users of the technology being trilled or developed. On-farm research is the most appropriate way to assess new forage cultivars and develop the most appropriate forage production and utilization techniques. Key or contact farmers should be used for transferring improved forage production technology to other farmers either through farmer-to-farmer contact or through formal field days and demonstrations. Finally, as detailed below, farmers should conduct the monitoring and some of the evaluation tasks associated with improved forage production programs.

Strong institutional support: Effective farmer participation is enhanced by strong institutional support at all levels. Central government support is required for coordinating the flow of funds for each forage production plan and to budget for future activities, as well as overall coordination of resource allocation to the program. This includes allocation of seeds, field technicians working with farmers, vehicles, adaptive research activities, and training. Regional government support is required to coordinate local activities, aggregate locally produced annual forage production plans, and support local technicians with subject matter specialists in areas such as forage production and forage utilization. Local offices effectively act as the liaison point between farmers and central government -they are the crossroads between "bottom-up" activities focusing on farmer participation and "top-down" activities, which coordinate and allocate resources made available by government. Local offices should be staffed by motivated and active technicians who work with farmers to extend each strategy, modify technical packages with on-farm adaptive research, and facilitate the preparation and implementation of annual forage production plans. Improved forage production programs are normally staffed from existing resources rather than adding new staff at the regional and local level.

Adequate financial and infrastructure support is important for the successful implementation of forage

programs. Transport is especially important for participatory programs. Small 4WD vehicles or motorbikes, where dogs and wildlife are not a problem, should be available to each local technician to encourage them to work in the field and to motivate their activity. Regional coordinators and subject matter specialists also need access to vehicles for periodic visits to local areas, demonstrations and farmer group meetings. Access to telephone or radio communications between regional and central offices is essential for effective and timely coordination of project activities especially during the preparation of annual plans. Regional offices should have a modest but up-to-date technical library to which local technicians and farmers have access. This is most easily organized through a library of original journals and books kept at central level from which appropriate papers and chapters are copied to each region for inclusion in a series of subject matter file.

Central government staff coordinating improved forage programs need access to word processing resources and printing or copying facilities for preparation of posters, newsletters, extension bulletins and technical briefing papers. A photocopier is invaluable for facilitating the flow of information between subject matter specialists and local technicians, and between farmers. Computers are needed at central and ideally regional level to coordinate budgets, organize and keep track of seed distribution, and analyze monitoring and research data. Training in the use of word processing, spreadsheet, and data analysis soft ware needs to be included with all computer purchases. Central and regional administrators need to organize and monitor farmer and local technician training. This will sometimes involve subject matter specialists but could also include international training courses. Because of the many components required for successful production of improved forage, large programs are normally most successful if the program coordinator is supported by special coordinators for key areas – seed, forage production, forage utilization and training. This central program organization can be duplicated at regional level if the program is sufficiently large. Otherwise a single regional coordinator can work with the special coordinators at central level and the local technicians at village level.

Planning approach to implementation: Successful implementation of forage production programs is enhanced by basing implementation activities on annual plans, which are developed at a local level by farmers with support from local technicians. Annual plans are used as an integral part of farming management and provide a focus for liaison between farmers and local technicians and regional subject matter specialists. The timing of forward planning, seed requirement calculations, seed ordering and distribution, and sowing are all developed with farmers during the annual planning process. Annual plans developed by each farmer or household are aggregated into village annual plans by self-organized farmer groups - for example pastoral associations and grazing management groups. Village annual plans are aggregated at regional level to make regional forage production plans, and finally pooled together at central level to prepare a national forage production plan for that particular year.

Motivated technicians located throughout the project area: Motivated technicians need to be locally based to extend forage strategies and conduct adaptive research with farmers. The local technician ultimately determines whether the role of the executing institution in the forage program is successful. They must facilitate diagnostic surveys or problem census activities with farmers, conduct initial on-farm demonstrations and promote a widespread understanding of forage utilization. Once the program is being implemented, local technicians should initiate demonstrations, which will have an early visual impact. This provides an important incentive for wider participation in the forage production program by farmers. A lot of seed and seedlings should be made available during the early years of the project to have a saturation effect on each locality. Motivated technicians will make good use of this seed, and its availability helps reinforce their position within the local community, which in turn strengthens their motivation.

On-farm adaptive research is needed to assess new cultivars and modify the technical packages to suit local social and environmental conditions. Adaptive research can also be used to emphasize certain benefits which farmers perceive with the program or to emphasize solutions to priority problems identified by farmers. For example, many farmers appreciate the shelter and privacy uses of browse species so demonstrations and adaptive research can be oriented towards optimizing these attributes – browse hedges can be demonstrated and optimal in-row spacing, cutting height and cutting frequency can be the subject of adaptive research. This approach to forage production helps farmers develop an understanding of the wide range of direct and indirect benefits of improved forage. By ensuring that farmers participate at all levels, benefits, which they perceive but which are not apparent to technicians will not be overlooked. Local technicians should also work with farmers to develop their understanding of farm feed budgeting and feeding priorities. This should be included in forage utilization activities. The value of improved forage needs to be demonstrated to farmers in relation to the normally more expensive agro-industrial by-products.

Integration with other activities: Improving the quantity and quality of forage is central to increased livestock productivity in Ethiopia. Without adequate forage farmers cannot realize the full benefits from animal health and breed improvement programs. Improved forage production programs should therefore be fully integrated with other livestock development activities. Most importantly, improved forage production should be a pre-requisite for participation in other programs. This not only acts as an incentive for wider adoption of forage production strategies but also increases the benefits from other, usually more expensive, programs. For examples, farmers seeking government-provided animal health services should first be required to have adequate and balanced forage available for their livestock. Similarly, farmers wishing to participate in artificial insemination or improved heifer programs should also demonstrate that

they have a sustainable supply of balanced forage for their animals. This integration also ensures that all technicians and administrators involved with national, regional and local livestock production include sustainable forage production in their strategies.

Financing mechanisms: Institutions executing improved forage production programs need to have access to project or other funds for local seed purchases. Unless simple administrative procedures exist to distribute and account for funds required for seed purchases, it is very difficult and time consuming to enter into forage seed production contracts with farmers. Without such seed production, forage programs are unlikely to be sustainable, unless a private sector seed industry exists. Where private seed traders and producers exist, it may be more administratively simple for executing agencies to issue selected companies with a head contract to produce certain quantities of certified seed. These companies can then sub-contract production of this seed to farmers. Financial mechanisms for other program procurement should be within the control of the program coordinator at central government level. This reduces the delays in procurement of inputs for forage programs and enables more accurate preparation of annual plans and their budgets.

Secure land tenure: Security of land tenure is one of the issues normally raised by farmers during problem census and diagnostic survey activities for improved forage programs. Land tenure issues have wide political, economic and social implications, many of which are outside the objectives of improved forage programs. However, security of land tenure is a very powerful incentive for adoption of improved forage strategies especially where they involve perennial browse and grass species. Freehold title provides the best incentive for individual farmers to adopt improved forage strategies on their cropping land. This is especially important for long term strategies such as contour forage strips and agro forestry.

Where freehold title is not possible, leasehold title also provides and incentive for forage production. Leasehold titles guarantee tenurial lease from the government for a given period of time typically up to 45 years but may have management covenants attached. If the covenants are not observed the leasehold is forfeited to the government. Leasehold titles are especially useful for common lands to be rehabilitated with over sowing strategies or to be managed as stock exclusion areas. Secure leasehold tenure acts as an incentive for the formation of grazing management groups or pastoral associations, and the lease is normally established in the name of the group or association. This not only give farmers or pastoralists a reason for forming these groups or associations but provides a mechanism for peer group pressure to regulate grazing management and implementation of improved forage strategies on common land.

One strategy, which is normally very successful, is to use grazing land rehabilitation contracts as a vehicle for implementing over sowing, agro forestry, or stock exclusion strategies on common land. These contracts provide grazing management groups or pastoral associations with leasehold title to certain common land. The leasehold title has land rehabilitation, improved forage production and grazing restrictions attached to it. These would normally include over sowing and stock exclusion strategies, provision for cut and carry harvesting of forage and browse at certain time of the year and a requirement for regular monitoring of plant cover and soil erosion. The leasehold title should be for a period of at least 10 years and should be strictly monitored by a regional administrator with support from local technicians. This approach works successfully in Asia and Turkey and should be included in problem solving sessions with farmers during the identification and preparation of improved forage programs.

Monitoring and evaluation: The impact and sustainability of improved forage production programs will depend on the existence of a database of information, which can be used to modify technical packages and demonstrate the benefits of each strategy being promoted by the program. The information required for this database can mostly be collected by farmers and local technicians and should include: area planted to each species and cultivar; DM production from each cultivar under different management strategies; local climatic data especially rainfall, maximum and minimum temperature and frost incidence; livestock numbers by species and type (male, female, castrate etc.); purchase price and weight for animals to be fattened; daily rations fed to animals being fattened; selling price and weight for fattened animals; daily rations fed to dairy animals; daily and total milk yield for dairy animals; veterinary expenses; and labor inputs for forage production and utilization.

This type of information can be conveniently collected by self-monitoring or auto-recording strategies in which farmers enter information in simple daily livestock record books designed for the purpose. As with other activities the livestock monitoring record book should be designed with farmers. It must be in their local language and should be based on their technical terms for the parameters being measured. This local technical lexicon is translated into international terms at the regional or central office responsible for recording and analyzing monitoring data. Thus in Ethiopia, for example, *timad* and *quintal* might be used rather than hectare or kilogram, with the appropriate conversion factors being applied by technicians analyzing the data. Separate monitoring books would normally be developed with farmers for forage production, livestock fattening and dairy production. The use of auto-recording strategies for livestock monitoring has been successfully used in several projects, including the Second Livestock development Project in Mauritania. The principal benefits of auto-recording monitoring are that data reflects socio-economic aspects of farming systems, which cannot normally be record by outsiders. Such data not only enables production to be monitored but it also is able to compare the productivity of different management and socio-economic systems. This information becomes very important for adapting technical packages to different socio-economic and environmental circumstances.

Forage production monitoring can be adequately done with simple sheets, which are completed on a weekly basis. The prepared form is the basis for evaluating the implementation of annual forage production plans and the preparation and modification of subsequent annual forage production plans. Harvesting data should be entered from the weekly summary sheets in monitoring books used for livestock fattening or dairy production. The weekly monitoring sheets are summarized onto monthly forage production sheets by the local technician working with the farmer. Local technicians take copies of this monthly summary for collation and analysis at regional or central level. Analytical results are later returned to the local technician for discussion with farmers. This helps farmers see how they are performing relative to their peers. It also enables the local technician to not only target people in most need of help but also identify the most successful management strategies for integration into subsequent demonstration and extension activities. Auto-recording forage production monitoring forms include: units(s) of production (area, length of strips, number of browse trees etc.); soil type; drainage score; farming system into which forage has been integrated; inputs (fertilizer, dung, other); labour inputs (weeding, harvesting, etc.); wood production by species; forage production by species and seed production by species.

Conclusion

Over the past five decades, various externally funded livestock development projects have been launched in Ethiopia. Among the projects, FLDP was successfully developed and implemented a number of forage and forage seed production strategies, which were integrated friendly with cropping systems. The key strategies were complementary to arable cropping, which increased their acceptance by farmers. The strategies were designed with farmers and demonstrated on farms to increase the spontaneous adoption of key strategies. Because of the diverse growing conditions and farming systems in Ethiopia, a range of strategies and species mixes were developed and implemented for the major agro-ecological zones. Moreover, contractual forage seed production scheme established to ensure adequate seed supply for the forage development programs. Generally, the project was the first of its kind in Ethiopia in implementing extensive forage development interventions which are specifically suitable to the smallholder mixed crop-livestock farmers and generated valuable lessons for similar livestock development programs in the country.

REFERENCES

Alemayehu Mengistu, 2004. Pasture and forage resource profiles of Ethiopia. EDM printing Press, Addis Ababa, Ethiopia.

Alemayehu Mengistu, 2006. Country Pasture/Forage Profiles, pp: 5-32.

Alemayehu Mengistu. 1998a. Natural Pasture Improvement Study rd around Smallholder Dairy Areas. MoA Small Dairy Development Project (SDDP), Addis Ababa, Ethiopia.

Alemayehu Mengistu. 1998b. The Borana and the 1991-92 Drought: Rangeland and Livestock Resource Study. Institute for Sustainable Development (ISD), Addis Ababa, Ethiopia.

Alemayehu Mengistu. 1989. Recommended Forage for Ethiopian Environments and Current Strategies for Utilization. Proceedings of the XVI International Grassland Congress, Nice, France.

Alemayehu Mengistu and Getnet Assefa. 2012. The Evolution of Forage Seed Production in Ethiopia. In: Getnet Assefa, Mesfin Dejene, Jean Hanson, Getachew Anemut, Solomon Mengistu & Alemayehu Mengistu (eds.). Forage Seed Research and Development in Ethiopia. Ethiopian Institute of Agricultural Research. ISBN: 978-99944-53-84-9.

Anderson FM, 1987. Farmer circumstances in Ethiopia and the improvement of animal feed resources. *In*: Kategile A, Said A N and Dzowela H D (editors). Animal Feed Resources for Small-scale Livestock Products. Proceedings of the 2nd Pastures Network for Eastern and Southern Africa Workshop, 11-15 November 1985, Nairobi, Kenya, pp: 209-219.

ATA (Agricultural Transformation Agency). 2012. Livestock value chain programs. Http./www.ata.gov. et/programs/valuechain programs/livestock.

Bikila Negasa, B Eba, S Tuffa, B Bayissa, J Doyo and N Husen, 2014. Control of bush encroachment in Borana zone of southern Ethiopia: effects of different control techniques on rangeland vegetation and tick populations, J Pastoralism: Res, Policy Pract, 4: 18.

CSA (Central Statistics Authority), 2008. Agricultural sample survey report: Private peasant holding (Statistical Bulletin), Addis Ababa, Ethiopia.

Fekede Feyissa, G Assefa, G Kebede, A Mengistu and D Geleti, 2015. Cultivated forage crops research and development in Ethiopia. In: Alemu Yami, Getnet Assefa and Lemma Gizachew (eds.). Pasture and range research and development in Ethiopia. Ethiopian Society of Animal Production, ESAP, 2015.

FLDP, 1991. Forage Seed Production Extension Manual. Fourth Livestock Development Project. Ministry of Agriculture, Addis Ababa, Ethiopia.

Funk, Rowland, Eilerts, E Kebebe, Biru, White and G Galu, 2012. Climate trend analysis of Ethiopia. Climate change adaptation series. U.S. Geological survey famine early warning systems Network-Informing (FEWSNET) Fact sheet 3053. 6p.

Gemedo DT, LM Brigitte and I Johannes, 2006. Encroachment of woody plants and its impact on pastoral livestock production in the Borana lowlands, southern Oromia, Ethiopia. East African Wild Life Soc, Afric J Ecol, 44: 237–246.

Manaye, Tollera and T Zewdu, 2009. Feed intake, digestibility and body weight gain of sheep fed Napier grass mixed with different levels of Sesbania sesban. Livestock Sci, 122, 24–29.

Odongo NE, J Tanner, DL Rommey, J Plaizier, P Van Straaten and B Mcbride, 2002. The effect of supplementing Napier grass (Pennisetum purpureum) with Rock Phosphate and steamed bone meal compared with commercial mineral mix on phosphorus absorption in cattle. Trop Anim Health Prod, 34: 329–338.

O'Reilly MV, 1987. Better Pastures for the Tropics. Yates, Australia.

Seyoum B and S Zinash, 1995. Chemical composition, *in vitro* digestibility and energy value of Ethiopian feedstuffs. *In*: Proceedings of the 3rd Annual Conference of the Ethiopian Society of Animal Production, 27-29 April 1995, Addis Ababa, Ethiopia, pp: 307-311.

Shem MN, EJ Mtengeti and M Luaga, 2003. Feeding value of Napier grass (Pennisetum macrourum) for cattle supplemented with protein and ⁄ or energy rich supplements. Anim Feed Sci Technol, 108: 15–24.

Tessema Zewdu and RMT Baars, 2004. Chemical component, *in vitro* dry matter digestibility and Ruminal degradation of Napier grass (*Pennisetum purpureum* (L.) Schumach) mixed with different levels of Sesbania sesban (L.) Merr.). Anim Feed Sci Technol, 117: 29–41.

Tessema Zewdu, RMT Baars, Alemu and Dawit, 2002. *In sacco* dry matter and nitrogen degradation and their relationship with *in vitro* dry matter digestibility of Napier grass (*Pennisetum purpureum* Schumach.) as influenced by plant height at cutting. Australian J Agric Res, 53: 7–12.

Tessema, Zewdu and Halima, 1998. Forage and pasture research achievements in north-western Ethiopia. In: Seboka, Deressa, A (eds.), Proceedings of the Fourth Technology Generation, Transfer and Gap Analysis Workshop on Agricultural Research and Technology Transfer, Attempts and Achievements in Northern Ethiopia. 18–21 March 1997, Bahir Dar, Ethiopia.

Tolera A and A Abebe, 2007. Livestock production in pastoral and agro-pastoral production systems of southern Ethiopia. Livestock Res Rural Develop, 19: 169-177.

Zinash S, B Seyoum, G Lulseged and T Tadesse, 1995. Effect of harvesting stage on yield and quality of natural pasture in the central highlands of Ethiopia. *In*: Proceedings of the 3rd Annual Conference of the Ethiopian Society of Animal Production, 27-29 April 1995, Addis Ababa, Ethiopia. pp: 316-322.