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# Improved forage crops production strategies in Ethiopia: A review

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**There are various strategies to integrate forage crops into crop-livestock farming system in Ethiopia. The method of integration used for a specific farming system mainly depends on the type of forage crops, food crops, soil type, rainfall pattern and other social and economic factors. Cropping systems are expanding and intensifying to feed growing human populations and overcome decreasing productivity due to soil degradation and poor husbandry. By adopting strategies, which integrate livestock and cropping systems, there is considerable potential to not only increase crop yields but also increase the quantity and quality of forage for ruminant livestock. The use of forage legumes frequently increases soil nitrogen available for food crops because of their ability to fix nitrogen. Moreover, multipurpose browse trees and shrubs increases fuel wood resources available to farming households, decreasing the need to use dung as fuel and increasing the availability of dung for use as fertilizer. Generally, improved forage legumes and browse species provide a sustainable source of protein which enhances the ruminant livestock productivity. The positive impacts of increased sustainable cropping include more crop by-products, more forage and browse legumes where forage production strategies are integrated with sustainable cropping, and a better mix of nutrients from these sources of forage. In general, different research studies demonstrate that integration of forage and food crops with different strategies increases the productivity and sustainability of farming systems and improves the quantity and quality of livestock feed available from such systems. Therefore, benefits from integrated forage and crop production systems are substantial, prolonged and complementary.**

**Keywords:** agro-ecologies, forage crops, forage integration strategies, crop-livestock production

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## INTRODUCTION

Livestock production contributes up to 80 percent of farmers' income in Ethiopia and about 20 percent of agricultural GDP. Ethiopia has the largest livestock population of any country in Africa. Nutritional factors are the binding constraint to sustaining livestock production in the country. During the latter part of the dry season, livestock feed is normally in short supply and is also of poor quality. Residues from cereals are the main source of forage but these are low in protein and have poor digestibility. Removing them from the fields also reduce organic matter content in the soil which degrades soil structure and increases the erodibility of cropped land. The production of adequate quantities of good quality dry season forages to supplement crop residues and pasture roughages is the only way to economically overcome the dry season constraints affecting livestock production. The use of deep rooted perennials such as browse legumes reduce the impact of the dry season, because browse species have root systems which better able to exploit soil water reserves than forage species (Alemayehu, 1989). Uncontrolled grazing of increasingly scarce common areas has contributed to the degradation of many range and pasture lands. Degradation in the form of soil erosion, deforestation, and declining soil structure and fertility has a social and economic cost which nations and individuals cannot afford. Increasing populations and declining land productivity results in increasing demand for arable land in Ethiopia. This increasing demand for cropping land to produce food for humans reduces the amount of land available for natural grazing and forage production. Livestock numbers have increased to meet the demand for draught animals resulting from increased cropping activity. These conflicting developments place an unsustainable demand on land resources, which is compounded by the transport of nutrients away from fields in the form of grain, crop residues and dung used for fuel.

Integration of livestock and cropping systems is essential for sustainable natural resource management and improved livestock productivity. Sustainable livestock and crop production in Ethiopia is dependent on dramatic changes in livestock management systems. The key components of these changes are a shift towards more intensive feeding systems, with more emphasis on cut-and-carry feeding, and a gradual shift away from uncontrolled grazing, particularly on uplands and sloping areas. This may need to be combined with decreasing livestock populations in some areas perhaps associated with small-scale mechanization of cropping systems, which currently rely on animal draught power for cultivation. The use of woody leguminous species in agro-forestry, alley cropping or browse coppice systems is one of the key elements of sustainable agricultural systems in Ethiopia. Legumes are especially emphasized because of their multipurpose utility, and their dual roles in animal nutrition and the maintenance or improvement of soil fertility and hence crop production. Fourth livestock development project in Ethiopia successfully developed and implemented a number of forage production and animal-feeding strategies, which were integrated with cropping systems and in almost all cases, avoided displacement of arable crops. 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. Therefore, this paper summarizes the various forage integration strategies in to the different agro-ecologies of Ethiopia and suggests possible interventions for future implementation.

## Backyard forage production

Backyard forage production is based on small plots and hedges of productive forage and browse planted within house compounds and around their boundaries. This is the most important initial strategy since it is developed in the farmer's household, and is very convenient for intensive feeding of dairy animals or fattening of meat animals. The higher fertility levels typically found in and around house compounds also helps with the successful establishment of backyard forage. This strategy has a major impact in exposing farmers to the management and productivity of new species and also provides a seed bank to help establish new plantings for other forage strategies. Woody leguminous browse species are particularly suited to this strategy because of their multipurpose benefits and rapid growth rates. Tall growing tropical grasses are also suited to backyard forage development. Tree legume hedges have been the most widely adopted backyard forage strategy and need to be used as an incentive for broad-scale forage development based on contour forage strip and under sowing strategies. This strategy introduces farmers to the concept of supplementing crop by-products and poor quality roughages with high quality forage in a location, which facilitates close attention to management.

Backyard forage provides significant quantities of both forage and fuel wood where they can be conveniently used. Other benefits perceived by farmers include shelter, increased privacy, wood products construction and implements and bee products. The multipurpose benefits of backyard forages provide a range of incentives for farmers to adopt this strategy. It should be one of the first strategies to be promoted by extension agents since it is easily established and managed, and provides the means to reduce grazing pressure on common grazing areas. Backyard forage can be cut and carried to tethered or housed animals, or cut and conserved for dry season use in mixes with crop residues and natural pasture hay or roughages. Experience from Ethiopia testifies to the utility of backyard forage species used by the fourth livestock development project (FLDP) and summarized in Table 1. Experience in New Zealand suggests that tree lucerne will produce up to 900 kg DM/tree each year (Townsend and Radcliffe, 1989) and has a forage value similar to alfalfa. The digestibility of the ration increased from 47 per cent for maize husks alone to 63 per cent for the 3:2 maize husk: leucaena ration (Phiri, 1992). Supplementation of guinea grass (*Panicum maximum*) hay fed to goats with 100 g DM/day *Sesbania sesban* leaves resulted in total DM intake of

**Table 1:** Key species for backyard forage establishment in different agro-ecologies of Ethiopia

| Altitude | Browse legumes | Forage legumes | Grasses |
|---|---|---|---|
| <2000m | Leucaena<br>Sesbania<br>Pigeon pea | Green leaf<br>Silver leaf<br>Alfalfa | Rhodes grass Elephant grass Panicum grass |
| 2000-2400m | Sesbania<br>Pigeon pea<br>Tree lucerne | Alfalfa<br>Vetch<br>Verano stylo | Phalaris grass<br>Elephant grass |
| >2400m | Tree lucerne | Alfalfa<br>Vetch | Phalaris grass<br>Oats |

Source: Alemayehu Mengistu, 2002

626 g DM/day compared with 498 g DM/day without the browse supplement (Ash, 1990).

The backyard forage strategy provides an opportunity to reach large numbers of farmers very quickly and can therefore have a great impact nationally, even in the short term. Demonstrations of about 100 browse legume seedlings or grass sets should be established in the housing compounds of contact farmers. This numbers is necessary to ensure sufficient high quality forage to supplement conserved roughages and crop by-products fed to household livestock. Forage seedlings or sets can be planted in any pattern to suit the needs of the household but simple boundary hedges/shelter belts or forage blocks are the most widely accepted designs for backyard forage plantations. The extension emphasis should be on browse legumes and large grasses and the production of bare rooted seedlings in backyard nurseries. This ensures that farmers develop the capacity to grow their own seedlings or sets for expansion of forage development using contour forage strips and other strategies. In this way, farmers develop familiarity with the propagation, growth and management of key species. Backyard nurseries are typically 4 to 5 square meters in size and are initiated with small packets of seed containing 50 to 100 grams of seed. It is feasible to distribute these seed packets to vast numbers of farmers each year. Wide distribution of seed and promotion of hedges, backyard forage banks, ensure the farmers' capacity to grow bare rooted seedlings for planting in other areas. Once these components of the backyard forage strategy have been adopted, extension efforts can focus on the use of backyard forage to reduce grazing pressure on common areas and increase livestock productivity from poor quality roughages. Wide acceptance of the backyard forage strategy also provides a sound foundation for farmers to establish grazing management groups or pastoral associations to control grazing on common lands and cropped areas. This then provides the basis for adoption of the contour forage strip and livestock exclusion area strategies.

**Under sowing and inter planting**

Under sowing and inter planting is the establishment of forage species in an annual crop or perennial plantation. This strategy provides the most convenient approach to rapidly increasing on-farm forage supplies over a large number of farmers and should have a major impact in the short to medium term. The use of legumes in this system will contribute to the improved fertility and structure of cropping soils. Farmers seeing on-farm trials of under sowing and inter planting accept the strategy readily and understand the benefits and techniques very quickly. This is normally the second strategy to promote after backyard forage has been adopted by farmers. Under sowing and intercropping are probably the most important of the forage development strategies. Under sowing works best with sprawling, low growing annual legumes but can also work well with climbing legumes (Table 2). The strategy is particularly suited to the production of tall growing cereals such as maize, sorghum or millet but also works with other cropping systems. Under sowing with legumes produces large quantities of high quality forage for utilization by either post harvest grazing or cut and carry systems. The under sown forage protects the soil from erosive rains, can contribute nitrogen for the food crop, and balances the forage value of crop residues such as stover and straw to increase its intake and utilization. The strategy works well with sprawling and climbing legumes but is also effective with other forage legumes and dual purpose legumes such as cow pea. Tree crops and some vegetables can also be under sown or inter planted with leguminous forages. The establishment of annual or perennial legumes under tree crops is a reliable strategy, which is well accepted by farmers. It is particularly appropriate to the more intensive horticultural and forestry systems where the under sown legume is intensively managed with cut and carried systems for livestock feed. The strategy primarily involves lower altitude systems where fruit, coffee, coconuts, enset or chat are grown. There is also broad application with

**Table 2:** Key species for under sowing and intercropping in different agro-ecologies of Ethiopia

| Altitude | Browse legumes | Forage legumes | Grasses |
|---|---|---|---|
| <2000 m | Not Appropriate | Cow pea<br>Verano stylo<br>Greenleaf<br>Wynn cassia | Not Appropriate |
| 2000–2400m | Not Appropriate | Siratro<br>Vetch<br>Greenleaf | Not Appropriate |
| >2400m | Not Appropriate | Vetch<br>White clover<br>Native clovers | Not Appropriate |

Source: Alemayehu Mengistu, 2002

eucalyptus and acacia plantations grown for fuel wood.

Where crop weeding practices are very thorough, forages should be under sown at the time of final weeding. This avoids any risk of the under sown legume competing seriously with the cereal crop but often means that the legumes have insufficient time to produce ripe seed prior to crop harvest. In areas of poorer weeding practices, under sowing should coincide with an earlier weeding. In this way sufficient legumes survive any subsequent weeding to provide an adequate seeding capacity prior to crop harvest. Early maturing cereals generally favor better forage production because they compete with the under sown forage legume for a shorter period of the growing season. The competitive balance between crop and under sown or intercropped forage legume is very sensitive to sowing time. This will vary with soil and crop type, season, and management practices, and is best determined using on-farm demonstrations. Farmers understand the benefits of under sowing or intercropping and adopt this strategy over a wide range of traditional cultivation and cropping practices. Farmers are attracted by the simplicity of the program and by the high yields of forage, which require no management input because the forage legume is protected from grazing by the crop. Farmers acknowledge that under sowing does not reduce crop yields but do not accept that the use of legumes helps maintain soil fertility, even though this has been successfully demonstrated. The incentive for adoption is large quantities of high quality forage in return for a minimal investment. High adoption rates can only be maintained if supplies of seed are available. Relatively large quantities of seed are required (typically 8 to 10 kg per hectare for annual legumes) unless early under sowing practices are used to ensure adequate seed set at the end of each season.

Good stands of under sown legumes produce 2,500 to 3,000 kg dry matter per ha from one cut in farmers' fields (Robertson, 1990). Farmers advise that grain yields are not depressed but that sprawling legumes such as the *Desmodium* and vetch dramatically reduce weed infestations effectively replacing weed growth with high quality forage. Verano stylo (*Stylosanthes hamata*) under sown into a three week old sorghum crop near Kaduna in Nigeria yielded 1.6 t/ha sorghum grain, 3 t/ha DM stylo forage, and 6 t/ha sorghum residue (Saleem, 1982). The forage and by-product resulting from this under sowing is a balanced growth diet for ruminants. Compare this total production of 1.6 t/ha grain and 9 t/ha forage with the production from the control crop without under sown forage – 2.0 t/ha grain and 7.5 t/ha sorghum residue. Middle altitude farmers in Ethiopia under sowing maize with *Desmodium uncinatum* harvested an average of more than 6 t DM/ha/year (Tadesse, 1988). This is enough quality forage to mix with 12 t DM natural hay or crop residue and fatten about 150 sheep or 15 oxen over a 120-day fattening cycle. Highland wheat crops in Ethiopia under sown with a range of indigenous *Trifolium* species yielded significantly more DM than control crops without under sown legumes. The most significant outcome of this work was the successful intercropping of wheat with forage legumes without any significant reduction in wheat yield. *Trifolium quartinianum* was particularly efficient with broadcast under sowing at Holetta yielding 1.1 t/ha wheat grain, 2.1 t/ha wheat straw and 3.1 t DM/ha clover hay (Kahurananga, 1988).

### Contour forage strips

Forage strips are broad based mixtures of herbaceous and tree legumes, and grasses planted on contour bunds or in narrow strips along the contour without any physical structures. This is a multipurpose strategy providing forage, shelter, soil stabilization and fuel wood. Forage strips planted along the contour contribute to soil conservation by directing ploughing along the contour and by reducing run-off down the slope. These increases infiltration and reduces soil erosion, especially where a thick sward of grass or herbaceous legumes is included in the forage strip. Contour forage strips are particularly successful when perennial, thick rooted grasses are mixed with woody leguminous species. Because this strategy integrates forage production in cropping areas, potentially weedy species such as stoloniferous grasses should not be used for forage strip plantings. Farmers perceive the principal benefits of forage strips to be the fuel and forage products rather than the conservation attributes. It is these benefits, which should be promoted as the incentives for adoption of forage strip strategies. They key problem with forage strips is the difficulty some farmers have in establishing them where livestock have free grazing access to fallow land or crop stubbles after harvest. This problem is best overcome by involving shepherds in forage strip establishment and promoting cut and carry feeding of animals tethered in the field. Thus contour forage strips are more easily promoted once backyard forage and under sowing is established to provide alternative forage sources to stubble and fallow grazing. Animals can be kept away from planted forage strips during their establishment if conspicuous species such as vetch are included in the forage strip mix. In some areas, alley farming can be developed by using long-lived browse species as part of the species mix for contour forage strips. Alley farming requires careful location and marking of contour strips which should be wide enough apart to allow ploughing and harvesting operations to take place without disruption. Alley farming is best established with bare rooted seedlings.

Typical on-farm demonstrations of contour forage strips would include up to 1 hectare of forage strips at 4 to 10 meter horizontal intervals between strips. Strips are up to 1 meter wide and should be continuous along the contour to maximize their conservation function. Contours can be marked out using a simple A frame and pendulum device. Alternatively, water levels made of two staffs with a water-filled tube between them can be used. Where alley cropping is developed using woody legumes along contour forage banks, seedlings or seeds of woody species should be planted at 1 meter intervals along each contour strip. Large bare rooted seedlings are most successful because they have a quick visual impact and are more easily protected from grazing animals. The most reliable species include those listed in Table 3. Pioneer species such as pigeon pea, Phalaris, and green leaf desmodium are particularly reliable under storey species when planted with leucaena or tree lucerne. Stoloniferous species such as rhodes grass are not suited to contour forage strips because of their weed potential in crop areas. Demonstrations need to focus on the production benefits of contour forage strips to overcome some farmers' fears that contour forage strips reduce their arable area and so decrease their income or food security. In fact, because of shelter, soil conservation and nitrogen benefits, well-designed contour forage strips frequently increase the productivity of the area between strips in addition to the products from the strip itself. This is especially true of alley cropping systems where the third dimension provided by browse legumes increases the productivity of the farming system. Contour forage strips produce between 2,000 and 5,000 kg dry matter per hectare of planted strip, or between 340 and 850 kg dry matter per hectare assuming 6 meter intervals and one meter wide strips. In addition to this benefit, there are yields of wood for fuel and construction, shelter benefits, nitrogen fixation and bee products (honey and wax).

**Forage crop production**

Where farmers use a cropping rotation or have sufficient land, they can grow a short-term forage crop. Short-term forage crops can be reliably introduced over a wide range of sites but are most appropriate for farmers who rely on dairy production for their income. Key species for forage crop production in different agro-ecologies of Ethiopia are summarized in Table 4. Annual leguminous species mixed with cereals provide the best quantity and quality of forage in highland areas but annual legume forages optimize forage production in middle altitude and lowland areas. Farmers in Ethiopia are shifting towards perennial forage production strategies because annual forage crops do not integrate livestock and cropping systems except where fallow is commonly used. In these areas fallow reduction strategies based on leguminous forage crops are appropriate. Oats and vetch have performed well over a wide range of AEZs, with oats showing good tolerance of relatively low fertility and poor drainage. Lablab is very productive at lower altitudes and competes well with weeds whereas alfalfa does not persist under rain fed condition in Ethiopia. Farmers accept oat/vetch and lablab strategies, especially where fattening or dairy enterprises are viable. However, as demand for subsistence food crops increases, forage strategies which can be integrated into cropping systems will be adopted in preference to annual forage crop strategies.

**Agro-forestry**

Agro-forestry is the combination of trees and agriculture in an integrated and sustainable farming system. Many of the forage production strategies can be developed as agro forestry systems. In particular contour forage banks and under sowing of tree crops or forest plantations can be designed as agro forestry systems where leguminous browse species provide an upper storey in a forage system or under sown legumes and grasses provide an under storey in a forestry or horticultural system. Agro

**Table 3:** Key species for contour forage strips in different agro-ecologies of Ethiopia

| Altitude | Browse legumes | Forage legumes | Grasses |
|---|---|---|---|
| <2000m | Leucaena<br>Sesbania<br>Pigeon pea | Siratro<br>Axillaris<br>Silver leaf<br>Greenleaf<br>Vetch<br>Verano stylo | Panicum<br>Setaria<br>Vetiveria |
| 2000-2400m | Tree lucerne<br>Sesbania<br>Pigeon pea | Greenleaf<br>Axillaris<br>White clover<br>Native clovers<br>Vetch<br>Alfalfa | Phalaris<br>Setaria |
| >2400m | Tree lucerne | White clover<br>Native clovers<br>Vetch<br>Maku lotus<br>Alfalfa | Phalaris |

Source: Alemayehu Mengistu, 2002

**Table 4:** Key species for forage crop production in different agro-ecologies of Ethiopia

| Altitude | Browse legumes | Forage legumes | Grasses |
|---|---|---|---|
| <2000m | Not Applicable | Siratro<br>Green leaf<br>Silver leaf<br>Vernano stylo<br>Lablab | Rhodes grass<br>Panicum grass<br>Setaria |
| 2000-2400m | Not Applicable | Greenleaf<br>Silver leaf<br>Vetch<br>White clover<br>Alfalfa<br>Lablab | Phalaris grass<br>Setaria |
| >2400m | Not Applicable | White clover<br>Alfalfa<br>Vetch | Phalaris grass<br>Oats<br>Cocksfoot |

Source: Alemayehu Mengistu, 2002

forestry maximizes the use of land by adding a third dimension to the above and below ground areas of utilization. This aspect is particularly important for farmers with limited land resources. Because many agro forestry strategies include leguminous species, they are also attractive to farmers facing problems of declining soil productivity. Experience in Ethiopia and elsewhere shows that the height and frequency of cutting agro forestry browse species has a significant impact on their productivity and forage value. For example, leucaena produces more DM at longer cutting intervals (>3 months) and moderate cutting height (75 to 100 cm) than more severe defoliation. Table 5 shows that the leaf nitrogen from three year old trees was also increased with longer cutting intervals (Karim et al, 1991). Similarly, total DM yield of sesbania increased with increased cutting interval with the highest yields recorded at 8 week cutting intervals. The 100 cm cutting height gave maximum yields from 12 month old sesbania, as shown in Table 6 (Galang et al, 1990). Pigeon pea also gives maximum yields with a cutting frequency of about 8 weeks yielding up to 50 t DM/ha each year (Udedibie and Igwe, 1989). Table 7 shows that although DM yield was maximized with a longer cutting interval, crude protein (CP) was

**Table 5:** Effect of cutting height and interval on DM yield of leucaena

| Cutting height (cm) | DM yield (g/tree) | | | Cut biomass N g/tree) | | |
|---|---|---|---|---|---|---|
| | 1 month | 3 months | Mean | 1 month | 3 months | Mean |
| 25 | 20 | 60 | 40 | 0.65 | 1.50 | 1.08 |
| 50 | 22 | 71 | 46 | 0.70 | 1.80 | 1.25 |
| 75 | 28 | 126 | 77 | 0.92 | 3.15 | 2.03 |
| 100 | 50 | 96 | 69 | 1.42 | 2.38 | 1.90 |
| **Mean** | **30** | **88** | **59** | **0.92** | **2.21** | **1.56** |

Source: Karim et al., 1991

**Table 6:** Effect of cutting height (cm) and frequency (weeks) on the total productivity (t/DM/ha) and leaf Content (%) of *Sesbania sesban* cv nubica

| Cut Interval | Total DM (t/ha/year) | | | Leaf Content of DM (%) | | |
|---|---|---|---|---|---|---|
| | 50cm | 100cm | 150cm | 50cm | 100cm | 150cm |
| 4 weeks | 2.4 | 3.3 | 3.3 | 87 | 88 | 91 |
| 6 weeks | 3.2 | 4.2 | 4.2 | 69 | 70 | 77 |
| 8 weeks | 4.1 | 4.9 | 4.4 | 54 | 60 | 65 |
| **Mean** | **3.2** | **4.1** | **4.0** | **67** | **71** | **77** |

Source: Galang et al, 1990

**Table 7:** DM yield and chemical composition of pigeon pea leaf meal cut at different time intervals

| Cutting Interval | DM Yield (t/ha) | Composition of DM (%) | | | |
|---|---|---|---|---|---|
| | | CP | CF | Ca | P |
| 4 wks | 2.3 | 24.3 | 24.8 | 1.39 | 0.31 |
| 6 wks | 2.4 | 21.9 | 26.1 | 1.24 | 0.22 |
| 8 wks | 2.7 | 20.1 | 27.1 | 1.09 | 0.23 |

Source: Udedibie and Igwe, 1989

maximized and crude fiber (CF) minimized with shorter cutting frequencies.

**Over sowing common grazing areas**

Over sowing is the simplest of the forage development strategies and can be undertaken at very low cost depending on the seeding rates used. It involves broadcasting or sowing improved forage species into common grazing lands, native pastures and degraded areas without any cultivation or other inputs. Key species for over sowing grazing areas in different agro-ecologies of Ethiopia are summarized in Table 8. Typically there is no attempt to modify grazing management but existing stocking rates should not be increased after over sowing. The strategy includes sowing roadsides from vehicles and is suited to aerial seeding where very large areas are to be developed. Aerial seeding is also another way of establishing improved extensive grazing areas using over sowing techniques. This strategy is most suited to pioneer legume species, which grow quickly and seed prolifically. Because of the low input nature of this strategy, incremental forage yields are not large but pioneer species with good grazing tolerance and natural seeding ability gradually colonize common areas and improve the overall species composition available for grazing. Natural spread of seed with water movement, grazing animals and wind action can be rapid, enabling very large areas of land to be developed so long as grazing management is possible to enable plants to become established and set seed. Farmers are more likely to gain long term advantages from over sowing strategies if there is some of grazing management group or pastoral association, which manages common grazing areas. This could be associated with dairy user groups but requires the majority of farmers using common grazing land to recognize that there is an overgrazing or low productivity problem, which can be solved with over sowing. The provision of seed and technical support for over sowing strategies is a sufficient incentive to encourage farmers to organize grazing management groups or pastoral associations. Such organizations are only successful if they are initiated by farmers in response to their perceived needs.

If suitable sites are chosen and effective grazing

**Table 8:** Key species for over sowing grazing areas in different agro-ecologies of Ethiopia

| Altitude | Browse legumes | Forage legumes | Grasses |
|---|---|---|---|
| <2000m | Leucaena<br>Sesbania | Siratro<br>Axillaris<br>Green leaf<br>Silver leaf<br>Seca stylo<br>Verano stylo<br>Wynn cassia | Rhodes Grass<br>Panicum<br>Setaria<br>Buffel grass |
| 2000–2400m | Sesbania | Siratro<br>Axillaris<br>Seca stylo<br>Verano stylo<br>Green leaf<br>Silver leaf<br>White clover<br>Alfalfa | Phalaris<br>Setaria |
| >2400m | Tree lucerne | White clover<br>Alfalfa<br>Maku lotus | Phalaris<br>Cocksfoot |

Source: Alemayehu Mengistu, 2002

management of common lands exists, over sowing of grazing areas is the most cost effective strategy for broad-scale forage production. Because this strategy is implemented on common grazing land by the government, farmer acceptance is not an important issue for implementation if the work is carried out by government staff. It is, however, a major issue for management of over sown areas. For this reason grazing management groups or pastoral associations, which are a prerequisite for successful long term establishment of over sown forage, should be closely involved in implementation as well as management of over sowing strategies. These associations can broadcast seed with hand cranked seed broadcasters. These inexpensive and simple implements are easy to use and very robust. They are equally suited to fertilizer spreading and so are an attractive implement for farmer groups and can act as an additional incentive for organization of grazing and pastoral groups. Village groups should aim to over sow up to 10 ha each year in low and medium altitudes and about 2 ha each year in the highlands. The most reliable species for over sowing have been the stylos, which have established and begun spreading on an extremely wide range of sites in Ethiopia. Wynn cassia and climbing/sprawling legumes such as green leaf and siratro have also shown promise. Experience in the sub-humid middle altitude areas of Ethiopia shows that even after a short time over sown *Stylosanthes guianesis* (cv Schofield) and *Desmodium uncinatum* can make up more than 15 per cent of pasture DM composition and yield more than 3 t DM/ha (Tadesse, 1988).

### Stock exclusion areas/forage banks

Stock exclusion areas are an important means of protecting degraded areas, key watersheds, and common land. They also provide an opportunity to develop forage banks for use during droughts or periods of seasonal forage shortage. Stock exclusion areas are particularly important for the conservation of highlands but are only accepted by farmers where they see sufficient benefits to organize grazing management groups or pastoral associations to control stock exclusion areas and voluntarily keep stock out. The introduction of browse species, productive legumes and improved grasses can rapidly increase the productivity of exclusion areas. Key species for stock exclusion areas in different agro-ecologies of Ethiopia are summarized in Table 9. The strategy is suitable for aerial seeding techniques which enable very large areas of land to be sown to forages quickly. Rehabilitation of degraded areas using forage species normally provides a good incentive for farmers and pastoralists to organize grazing management groups or pastoral associations. Because degraded land has low value as a common grazing resource farmers are usually willing to voluntarily exclude livestock from these areas. Rehabilitation of degraded areas with forage species provides an incentive for these initiatives, especially when farmers understand the benefits of forage

**Table 9:** Key species for stock exclusion areas in different agro-ecologies of Ethiopia

| Altitude | Browse legumes | Forage legumes | Grasses |
|---|---|---|---|
| <2000m | Leucaena | Siratro | Plicatulum |
| | Sesbania | Axillaris | Buffel Grass |
| | | Seca stylo | Setaria |
| | | Verano stylo | |
| | | Cook stylo | |
| | | Wynn cassia | |
| | | Green leaf | |
| | | Silver leaf | |
| 2000 – 2400m | Sesbania | Siratro | Phalaris |
| | Tree lucerne | Axillaris | Setaria |
| | Leucaena | Seca stylo | |
| | | Verano stylo | |
| | | Vetch | |
| | | Green leaf | |
| | | Silver leaf | |
| | | White clover | |
| >2400m | Tree lucerne | White clover | Phalaris |
| | | Alfalfa | |
| | | Maku lotus | |

Source: Alemayehu Mengistu, 2002

development.

Without farmer initiated grazing management groups or pastoral associations to control grazing, stock exclusion areas and forage banks are unsustainable. The extension effort therefore need to focus on the benefits of collaborative management of common lands and initially focus on degraded areas where benefits will be maximized and the likelihood of farmer resistance will be minimal. Cultivation is not necessary to establish forage banks or rehabilitate stock exclusion areas, especially on very bare sites, but broadcast sowing should take place after commencement of the main rains to ensure that there is enough soil moisture to sustain germination. Direct seeding with chisel tyned cultivators may be necessary in degraded areas with scalded or hardpan surfaces. Leguminous browse and tall grass species should always be included in stock exclusion areas to maximize the production potential and drought resistance of the species mix. Woody species can be planted by direct seeding but generally develop more successfully where they are planted as bare rooted seedlings early in the main rainy season. Annual cut and carry forage production from improved low and medium altitude sites in Ethiopia is in excess of 6000 kg per hectare (Robertson, 1990). Other benefits include soil conservation, better recharge of shallow aquifers, and production of fuel wood and bee products where browse species are included in the stock exclusion area.

Forage banks should be established at the beginning of the wet season. *Stylosanthes hamata* cv Verano and *S. guianesis* cv Cook are particularly suitable for forage banks and should be established with 8 to 10 kg seed per hectare. Forage banks are left un-grazed during the growing season to provide a supply of high quality forage during the dry season. Once established, these species can support up to 5 TLU/ha for up to 4 hours per day during the dry season (Otsyina et al, 1987). Burning is not necessary for establishment but kraaling animals on the area to be established as a forage bank prior to sowing helps reduce weed competition and adds manure to the soil. Forage banks are particularly important for maintaining priority animals in the household herd for example lactating animals and weaners. Browse legumes such as leucaena and tree lucerne also act as good forage banks if they are left uncut during the growing season. Many farmers regard backyard browse plantings as forage banks and this is an appropriate use for backyard forage strategies, which should be promoted by extension agents. Annual targets for stock exclusion areas of 2 to 10 hectares per village area are possible but much larger areas have been rehabilitated where strong village support has resulted in the formation of grazing management groups to voluntarily exclude livestock from areas to be developed. The improvement of stock exclusion areas is suited to cut and carry systems and is rapidly adopted by farmers where there is a history of fattening livestock for local markets. The location of intensive fattening or dairying enterprises adjacent to stock exclusion areas facilitates the efficient use of cut forage and provides an additional incentive for farmers to

**Table 10:** Key species for permanent pastures in different agro-ecologies of Ethiopia

| Altitude | Browse legumes | Forage legumes | Grasses |
|---|---|---|---|
| <2000m | Not Applicable | Siratro<br>Greenleaf<br>Silver leaf<br>Seca stylo<br>Verano stylo | Rhodes grass<br>Panicum<br>Setaria |
| 2000 – 2400m | Not Applicable | Verano stylo<br>Green leaf<br>Silver leaf<br>Vetch<br>White clover | Phalaris<br>Setaria |
| >2400m | Not Applicable | White clover<br>Alfalfa<br>Vetch<br>Maku lotus | Phalaris<br>Oats<br>Cocksfoot |

Source: Alemayehu Mengistu, 2002

collectively manage their common grazing resources. Once farmers have agreed to exclude livestock from an area, it should not be re-opened for grazing. Forage produced from stock exclusion areas should always be cut and carried to livestock to maintain the protected nature of the improved forage resource.

### Permanent pastures

Permanent pastures comprise a broad range of annual and perennial legumes and perennial grasses. Productive mixed pastures can be readily established, particularly in the low and medium altitudes with warmer growing conditions. Grazing management is a significant problem for sustainable pasture production in some regions, which is best overcome with cut and carry systems. Permanent pastures are most useful for dairy farmers who rely on optimal productivity of their livestock investment for their livelihood. Key species for permanent pastures in different agro-ecologies of Ethiopia are summarized in Table 10. Permanent dairy pastures should include a mix of legumes and grass species with high palatability and productivity.

### Roadside sowing

Roadside sowing is a successful means of implementing the over sowing strategy. It is quick and effective and provides an impressive visual impact which can be used to excite farmer interest and provide an incentive for the formation of grazing management groups or pastoral associations. This strategy can be highly cost-effective, particularly when using species with the ability to spread under grazing. Sowing a broad grid of suitable roads provides a convenient mechanism for introducing improved forage species to a large area since the rate of spread from a very long narrow transects is high. 10 km of roadside sowing equates to about one hectare of over sown grazing land. Seeding rates are typically 0.5 to 1.0 kg per kilometer of roadside. Mixed seed should be emptied from sacks or buckets from the back of a reasonably fast moving vehicle. In this way the vortex currents carry seed onto the roadside verge. Roadside sowing is most suitable for quickly establishing and prolific seeding species, which tolerate grazing. The stylos are the most successful species used in roadside sowing in Ethiopia.

### Aerial sowing

Aerial sowing enables very large areas to be over sown with improved forage seeds. The success of establishment depends largely on the selection of suitable sites. The most suitable sites have rough often gravelly surfaces. Sites with compacted or hardpan surfaces do not enable good establishment of aerial sown or broadcast seed. Stylosanthes are particularly successful for aerial over sowing being extremely resilient to grazing and a successful pioneer species. Aerial sowing is particularly suited to the rehabilitation of large catchments, which include relatively inaccessible areas. Where grazing is restricted or there are protected niches because of thorn bushes or rocks, leguminous browse species should also be included in aerial sowing mixes. Leucaena is especially appropriate for this purpose. Seed is best dispersed from fixed wing aircraft, which travel at sufficient speed to create air currents for seed dispersal. If helicopters are used, spinners are normally required for efficient seed distribution. Flag bearers on the ground or the use of prominent landmarks are necessary to plan and manage aerial seeding operations. In some other countries, including Australia and New Zealand, aerial seeding has been used successfully to over sow pastures on millions of hectares of uplands and range areas. Temperate, subtropical and tropical species, especially herbaceous legumes, have been successfully established with aerial sowing. Aerial sowing enables small quantities of seed to be uniformly and efficiently spread very quickly and economically. The low seeding rates necessary for this type of sowing are a major advantage for those species with the capacity to rapidly increase density and spread. These include the stylos, the desmodium, some trifolium, and Wynn cassia. Experience in Ethiopia shows that even on the most degraded sites, Verano stylo will establish and seed within three months of aerial sowing. Successful sowing was undertaken shortly after commencement of the main rains.

## CONCLUSION

Rain fed cereal and tree cropping systems in lowland areas present significant opportunities for integrating forage and food crop production. Longer growing periods and suitable thermal and soil conditions in much of this area enable under sowing and intercropping strategies to be adopted successfully. A broad range of suitable forage legume species exist and have been successfully demonstrated and adopted throughout this zone in Ethiopia. Alley cropping with browse legumes and contour forage strips are also appropriate in this zone combining conservation cropping with production of forage of browse as well as other tree products (fuel wood, timber and honey). Intensification of cropping systems through agro-forestry and intercropping or under sowing offer significant increases in productivity and sustainability in lowland areas. Under sowing and intercropping strategies used in lowland farming systems are also suited to middle altitude systems. Tree crops can also be under sown with sprawling leguminous forages, which maintain soil structure and fertility as well as producing forage. Permanent pastures and stock exclusion areas developed for improved forage production reduce grazing pressure on cropped areas and, where browse legumes are used, provide an alternative fuel source which releases dung resources for fertilization of cropped areas. Forage strip and alley cropping strategies are also suited to middle altitude cropping systems and have the advantage of being able to use a wider range of species than the lowland or highland systems. Highland cropping systems are less suited to under sowing or intercropping but forage crops grown as relays or in rotation with cereal crops offer opportunities for better integration of livestock and cropping systems. Contour strips of browse or forage legumes combined with thick grasses increase the sustainability and productivity of most soils whilst also providing high quality forage to supplement low quality roughages and crop residues. Poorly drained areas and uplands can be developed as permanent pastures and stock exclusion areas which, although not directly integrated with cropping areas, reduce grazing pressure on cropped land. Inclusion of woody browse legumes in stock exclusion areas not only increases quality forage production but also provides an alternative fuel source, which enables dung resources to be used on cropping areas. In this way, well managed permanent pastures and stock exclusion areas provide an important resource, which is integral to sustainable crop production. Increasing cropping intensities to support growing populations demand more draught animals, which places an unsustainable burden on the reduced areas available for grazing. A combination of small scale mechanization and increased use of browse legumes on upland stock exclusion areas are essential if highland agricultural systems are to be sustained.

## REFERENCES


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

Ash, A.J. 1990. Effect of Supplementation with Leaves from the Leguminous Trees *Sesbania grandifolia, Bizza chinensis,* and *Glericidea sepium* on the Intake and Digestibility of Guinea Grass Hay by Goats. An. Feed Sc. And Tech. 28 (3-4): 225-232.

Galang, M.C. et al. 1990. The Effect of Cutting Height and Frequency on the Productivity of *Sesbania seban* var. nubica in a Sub-Tropical Environment. Nitrogen Fixing Tree Research Reports Volume 8.

Karim, A.B. et al. 1991. Effect of Cutting Height and Cutting Interval on Dry Matter Yield of Leucaena leucocephala. Agro forestry Systems 16 (2): 129-138.

Kahurananga, J.C. 1988. Intercropping Trifolium spp. In Wheat and its Suitability for Smallholder Farmer Conditions of the Ethiopian Highlands. In: proceedings of Joint Workshop on Utilization of Research Results on Forage and Agricultural By-Product Materials as Animal Feed Resources in Africa. ILCA, Ethiopia.

Otsyina, R.M. et al. 1987. Manual of Forage Bank Establishment and Management. ILCA. Addis Ababa, Ethiopia.

Phiri, D.M. 1992. The Effect of Browse Supplementation on Maize Husk Utilization by Goats. Agro forestry Systems. 17: 153-158.

Robertson, A.D. 1990. Final Report on Forage Development Activities and Proposals. FLDP, Ministry of Agriculture, Ethiopia.

Saleem, M.A.M. 1982. Effect of Time of Planting Stylosanthes hamata cv. verano on Sorghum Grain and Legume Yield. ILCA Annual Report, Ethiopia.

Tadesse, A. 1988. The Underexploited Potential of Improved Forages in the Mid-Altitude and Lowland Areas of Ethiopia. In: Proceedings of Joint Workshop on Utilization of Research Results on Forage and Agricultural By-Product Materials as Animal Feed Resources in Africa. ILCA, Ethiopia.

Townsend, R.J., and J.E. Radcliffe. 1990. Tagasaste Forage Production Systems. NZ J. Ag. Res. 33 (4): 627-634.

Udedibie, A.B.I., and F.O. Igwe. 1989. Dry Matter Yield and Chemical Compositor of Pigeon Pea Leaf Meal. An. Feed Sc. And Tech. 24 (1-2): 111-119.