MoARD

TECHNICAL BULLETIN No.35

Forage seed production and preservation techniques

ESGPIP

ETHIOPIA SHEEP AND GOAT PRODUCTIVITY IMPROVEMENT PROGRAM

Further information:

Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP)

Tel. +251 011 416 6962/3
Fax: +251 011 416 6965
E-mail: *pvamrf_ethiopia@ethionet.et*

Website: http://www.esgpip.org

Foreword

This Technical Bulletin titled "*Forage seed production and preservation techniques*" is produced by the Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP). The ESGPIP is a USAID funded Project with the objective of improving the productivity of Ethiopia's sheep and goats.

Forage production is dependent on availability of planting material. Forage seed production is a specialized activity that somehow differs from regular forage production in that care is required in harvesting, processing and preservation of the seeds. General aspects of forage production are presented as technical bulletin number 17 of the ESGPIP. The current technical bulletin specifically focuses on aspects of forage seed production that need to be taken into account. The bulletin also contains some theoretical background like material in 3 believed to be useful for those who want to explore a bit more theoretical detail. Ordinary users including kebele development agents can limit themselves to sections dealing with the practical aspects of land preparation, planting, management, harvesting, processing and preservation of forage seeds. Summarized agronomic and seeding characteristics of common tropical and subtropical forage crops is attached as an annex.

It is believed that the information contained in this bulletin is also useful for other users that want to be engaged in business ventures based on forage seen production.

At this juncture, I would like to thank all those involved in the preparation and review of this technical bulletin.

Desta Hamito (Prof.),
Chief of Party,
ESGPIP
June, 2010

Table of Contents

FRAGE SEED PRODUCTION AND PRESERVATION TECHNIQUES

Prepared By: Solomon Mengistu and Alemu Yami	Edited by: R.C. Merkel

1. Introduction

Feed availability in terms of both quantity and quality are the most important constraints to sheep and goat production. Forage production is one of the most important approaches to increase feed availability. The growing interest in improved forages supply requires sustained availability of planting material which is true to the variety, free from weeds, inexpensive and that can reliably establish good forage when planted.

The gap in the supply of forage seeds must be corrected through encouraging seed producers, both smallholders and entrepreneurs, to build their production capacity by using available technology and knowledge. This field manual is prepared with a view to provide basic technical information on forage seed production, processing and subsequent conservation, in a simple, concise way such that development agents and entrepreneurs will find it useful in their day-to-day fieldwork.

2. Alternative systems of forage seed production

There are a variety of approaches by which good quality forage seed is produced in adequate quantities to meet the current demand for scale up /out of forage technologies. Potential alternative approaches are the following.

2.1. Contractual system of forage seed production

This system was introduced by the Fourth Livestock Development Project (FLDP) of the Ministry of Agriculture in 1987-88 with the aim to produce quality seed at the level of individual farmers and cooperatives at a reasonably low cost of production, and at the same time to demonstrate improved forages production and utilization techniques to the producers. Large quantities of forage seed were produced during the FLDP project period. However, farmer to farmer seed exchange was minimal. The farmers continued to rely on the government to market their product and this did not continue.

Reorientation of the seed contract system into one that involves a sort of tripartite agreement involving farmers, the extension service and livestock producers appears to be a more viable and sustainable approach. In this case the responsibility of the extension service would be to link seed producers with livestock (and forage) producers in addition to giving technical backstopping.

`

2.2. Opportunist seed production

In this system, forage seed production is coupled with livestock production in a dual business approach. Seed production takes place when the farmer expects a good seeding year and favorable market for seed. If not, fodder production for feeding livestock is practiced. Additional investment needed for this enterprise is low. What is required of the management would be control of plant density, maintenance of good crop hygiene, proper nutrition, irrigation and more intensive crop management

2.3. Specialized seed production enterprise

A specialized seed production enterprise requires high investment with regard to equipment, fertilizer, chemicals, power and labor. In this system, the seed enterprise is surely a profitable business and the crop is considered to be a high value crop. A more precise management skill is required including an utmost care in site selection.

3. Theoretical principles of forage seed production in relation to suitable site selection

3.1. Climatic requirements of seed crops

Seed production is generally encouraged by sunny weather. Areas with abundant radiation, especially in the later stages of crop development, are expected to have high seed production by encouraging rapid growth rates, flower opening and increased bee activity. The seed production site should be in the most favorable location so as to:

- have full expression of cultivar/ accession characters,
- have good harvest conditions, and
- obtain the highest possible yield

Climatic factors that affect forage seed production include day length, radiation, temperature humidity rainfall and wind.

3.1.1. Day length (photoperiod): This is the amount of sunshine an area receives. Photoperiod is the main determinant in whether flowering occurs and the strength of flowering response. This may not be a problem under Ethiopian conditions

3.1.2. Radiation: Seed yield depends both on high early crop growth rate, which determine flower number, and continued photosynthesis during grain filling. Flower opening and bee activity flourish in bright sun light. Areas with frequent cloud cover have a lower seed production potential. Differences in genotypic response to radiation levels are expected in tropical pasture species. Most of the tropical pasture legumes are shade intolerant and growth and seed production are drastically reduced by low radiation levels.

E.g. *Desmodium intortum* and *Pueraria phaseoloides* are tolerant to partial shade

3.1.3. Temperature: Temperature affects vegetative growth, floral induction, inflorescence growth and differentiation, flower opening, pollen germination and subsequent seed set and maturation. The effect may vary within and between species. Optimum temperature for vegetative growth is usually different from the optimum temperature for high seed yield.

- ***Effect of temperature on DM yield:*** Temperature determines the rate of plant growth through its effect rate of photosynthesis and rate of increase in leaf area that determine the rate of DM accumulation.
- ***Effect of temperature on reproduction:*** flowering is enhanced or prevented according to the photoperiod response group to which a species belongs. High night temperature can prevent or delay flowering in some species. Warm weather favors flowering, pollination, seed setting and ripening. Too high temperature has depressing effects on seed production. some crops have a chilling or low temperature requirement E.g. fodder beet (*Beta vulgaris*)

3.1.4. Humidity: High humidity levels are crucial for pollination of many tropical species. Atmospheric humidity has indirect effects on pathogens and insect population. It is negatively related to the incidence of seed pod opening and loss of seed before harvest. Areas with a drier atmosphere and higher radiation levels are utilized for legume seed production with irrigation.

3.1.5. Rainfall: Plant species productive life is influenced by moisture supply

- rainfall influences the water supply to plant roots and to the atmospheric humidity
- seed crops require ample water in the vegetative phase followed by relatively dry period for the reproductive phase.
- more rain in the reproductive phase means increased risk of diseases. Rainfall distribution should, therefore, be considered in site selection for seed crops.
- moisture stress promotes vigorous reproductive growth
- four to six months wet season is needed to produce the necessary strong vegetative framework for heavy seed crop
- an average annual rainfall of at least 800 mm with an upper limit of 1500-2000 mm provides sufficient moisture for seed crops.
- supplement with irrigation where rainfall is inadequate. Irrigation has the added advantage of allowing the control of the water supply, thus, avoiding excesses as well as deficiencies

3.1.6. Wind: Strong wind during the reproductive phase can cause severe crop losses through lodging, shattering and seed shedding. Lodging is aggravated by heavy rain.

3.2. Soil requirements

- good physical characteristics for cultivation; heavy soil is slow to warm up at the start of the growing season and this soil can delay early growth and subsequent maturity
- deep soil favors massive root system growth
- for seed production, a soil of medium fertility is preferred –neither acid nor alkaline
- level land preferred especially if ground seed recovery (of fallen seed) is to be employed (*Stylosanthes humilis, Macroptilium atropurpureum* cv. siratro)

- well-drained soils are favored by most pasture species. However, there are groups of species/varieties with special adaptation to specific drainage levels. E.g. *Brachiaria mutica* favors waterlogged soils
- some species are not suited for cracking soils e.g. *S. humilis*

3.3. Topographic features:

The location of the proposed site in the landscape determines the vulnerability of the site to adverse effects of wind, frost, extremes of soil moisture, and sun light.

3.4. Effect of mode of reproduction on site selection:

The mode of reproduction of pasture species need to be carefully considered in site selection. Breeding systems of tropical pasture species vary from self-incompatible cross-pollination to close. Self-pollination characteristics of many tropical legumes is often characterized by fertilization taking place before the flower opens ensuring total exclusion of foreign pollen.

3.4.1. Modes of reproduction

Self-fertilization: most self-fertilized species are cleistogamous and anthesis takes place within the closed flower bud, E.g. *Neonotonia wightii* cv Tinaroo. Isolation distances for cultivars of this kind need only to be sufficient to control contamination by adjacent seed. Other species like *Leucaena leucocephala* have exposed flowering heads, but are self-pollinated.

Cross-fertilization: there are two groups of cross-fertilized species:

1. ***Cross-pollinating, self-compatible***: some grasses and legumes are cross-pollinating with a high degree of self compatibility, e.g., *Desmodium uncinatum* and *Sorghum almum*.

2. ***Cross-pollinating, self-incompatible***: Some cross-pollinated grass species are totally self-incompatible (e.g., *Panicum coloratum* var makarikariense); while some other cross-pollinated grass species can be predominantly self-incompatible with limited self-compatibility (e.g., *Setaria anceps*).

3.4.2. Site requirements for isolation of cross-pollinated crops:

Absolute isolation is not feasible since pollen can be transported by wind for more than 300 kms. The attempt will be to reduce a gradient of possible contamination by maintaining minimum isolation distance limits.

3.4.3. Considerations in deciding isolation distance

- **Grade of seed**: There are seed grades in the process of variety development each of which require varied genetic purity standards (Table 1).

Table 1. An example of isolation distance requirement for an out-crossing cultivar of *Setaria anceps*.

Seed grade	Isolation distance	
	Large field size >2ha)	**Small field size (<2ha)**
Seed for fodder	50 meters	100 meters
Seed for seed multiplication	100 meters	200 meters
Certified commercial seed*	50-1600	100-1600
Breeder seed	Several kms	Several kms
**varies from country to country*		

- **Size of seed production field:** The crop itself is considered the best natural barrier. By convention, if the size of field is increased beyond 2ha, 50% reduction in minimum isolation distance is allowed. Discarding border rows provides another means of reducing isolation distance. The discarded border area could be conserved for hay or harvested as uncertified seed.

- **Level of pollen production:** Plants are mostly fertilized by neighboring pollen so high pollen activity helps dilute foreign pollen.

- **Pollen buoyancy and wind direction in wind-pollinated crops:** Contamination is positively related to pollen buoyancy (easy transport), crop height (pollen capture), atmospheric turbulence and wind direction. Accordingly, for wind pollinated crops, the minimum isolation distance must be set based on wind direction during blooming, occurrence of physical barriers such as wind breaks, and natural features.

- **Insect activity and hive location in insect-pollinated crops:** Contamination is influenced by insect activity and beehive location :
  - Insect activity:
    - ➢ some legumes like *Desmodium uncinatum* need tripping (shaking of flower parts by bees leg that facilitates contact of male and female reproductive structures) by insects although they are not out crossed
    - ➢ cross-pollinated crops like alfalfa need sufficient bee activity for increased seed production.

    To increase bee population, reduce competitive bee forages by removing flowering branches; at vegetative stage of the seed crop, increase flowering branches of bee forages as alternative sources of nectar and pollen.

  - Beehive location:
    - ➢ domestic bees are strongly territorial, returning repeatedly to the same areas.
    - ➢ contamination can be minimized by placing the beehive away from the border of inter-crossing insect-pollinated crops (Figure 1).

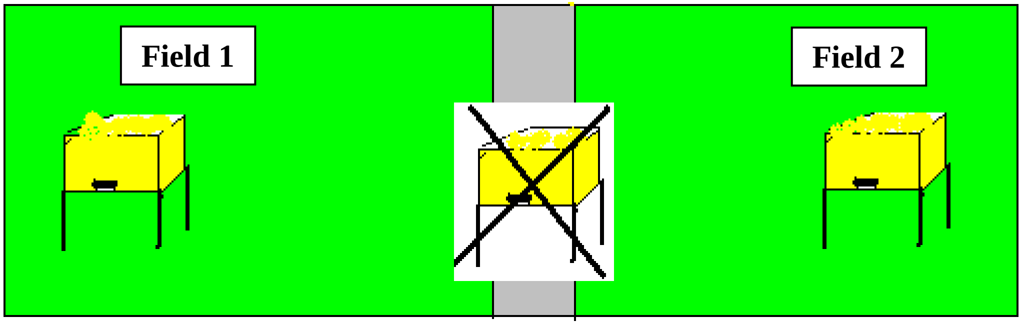


Figure 1. Placement of beehive in the field of out-crossing seed crops

3.5. Summary notes in site selection

The objective in site selection is to aim for the site that could give the highest seed yields. Generally, the best forage seed crops are produced in environments with sufficient radiation, temperature and rainfall for vegetative growth, favorable photoperiods and higher temperature for floral induction and calm, dry weather during maturation and harvest.

Outstanding issues to be considered in site selection:-

- Ensure that the site has most favorable environmental conditions (climate and soil) for growth, development and high amount of seed production from the intended species. Accordingly, the material for multiplication must be chosen to match the prevailing conditions for climate, day length and soils.
- do not hastily decide to produce seed in unsuited areas (climate, soil, market/demand), else failure is likely to be encountered.
- the area must consist of soil with physical and chemical characteristics suited for the crop.
    - to have full expression of cultivar/ accession characters
    - to have good harvest conditions
- conditions which promote good crop growth for vegetative parts such as stem, leaves and roots are not conducive to seed production.
- vegetative phase needs more water whereas seed production (reproductive phase) favors low rainfall or drier areas.

4. Basic technical procedures of forage crop establishment

4.1. Seedbed preparation

Having carefully selected the seed production site (Section 3), the next important step is to prepare a seedbed favorable for seed germination, seedling emergence, and growth. Grass seeds and some of the herbaceous legumes, such as clovers are generally very small justifying preparation of a seedbed of suitable fineness. The following is a general recommendation for seed bed preparation:

- ***Clearing.*** Clear trees, bushes and coarse herbs prior to ploughing.

• ***Ploughing***- first deep ploughing, then shallow ploughing to a fine, firm, even, and level seedbed.
• ***Rolling***- done after sowing to consolidate the soil and provide better soil/ seed contact.

4.2. Fertilising and manure application

If the soil is depleted of nutrients by continual cropping or soil erosion, basal applications of the macronutrients especially nitrogen (100-150 kg/ha urea) and phosphorus (50 kg/ha triple superphosphate) are helpful for successful establishment on most soil types of Ethiopia. Farmyard manure applied at the rate of 5-10 tons/ha is a less expensive option for the smallholder.

4.3. Planting

Planting can be through the use seeds, vegetative parts or seedlings. These are briefly presented below.

4.3.1. Planting using seeds

The following should be considered while using seeds for forage establishment:

- **True variety**: The seed must be true to the variety one is intending to plant; obtain seed from a reputable source.
- **Seed quality**: Quality is a function of purity (free from weed seeds, broken seed, chaff, soil, etc) and viability (ability to readily germinate). One has to use high quality seed to establish the pasture. Commercial seeds are usually accompanied by ‘passport data’ that include a recent seed analysis statement. Presence of weed seed, especially from exotic sources, should not be tolerated so as not to introduce new, potentially serious weeds like congress weed (*Parthenium spp.*) into the pastureland.

- **Seed dormancy:** Seed dormancy or inability to germinate is a natural protective phenomenon to prevent premature germination ensuring long-term survival of the species. Seed dormancy could be due to either an inactive embryo that fails to germinate (e*mbryo dormancy*) or a hard seed coat restricting entry of water and air (*Dormancy due to seed coat characters*). The former type of dormancy can be solved by storing freshly harvested seed for some period (*after ripening period*) depending upon the species history. Germination failure due to hard seed coat could be overcome by a number of techniques.

    - ***Mechanical scarification***: The seed coat is abraded by passing over abrasive surfaces.

        - rubbing with sand paper if sowing small quantities of seed (Figure 2).
        - For large quantities, use drum scarifiers (seed-mixer drums with the inside surface lined with abrasive material) (Figure 3).

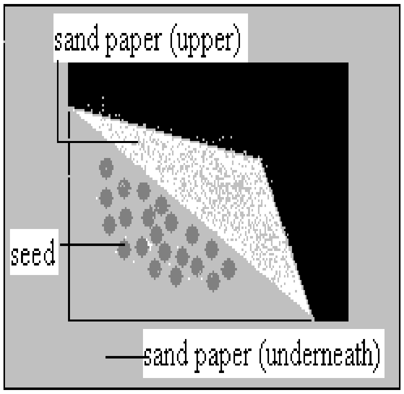


Figure 2. Seed scarification by rubbing the seed in between two pieces of sandpaper.

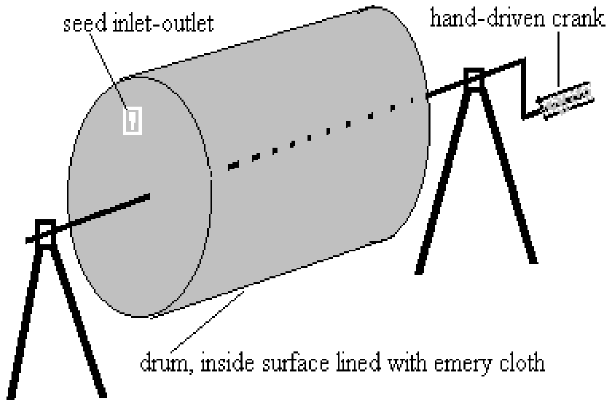


Figure 3. Seed scarification by using a drum scarifier.

- ***Acid treatment*:** immersion of seed in concentrated acid such as sulfuric acid, the duration of treatment depending on species (Figure 4).

- ***Hot water treatment: immersion*** of seed in water, the temperature and duration of treatment depending on species (Figure 5).

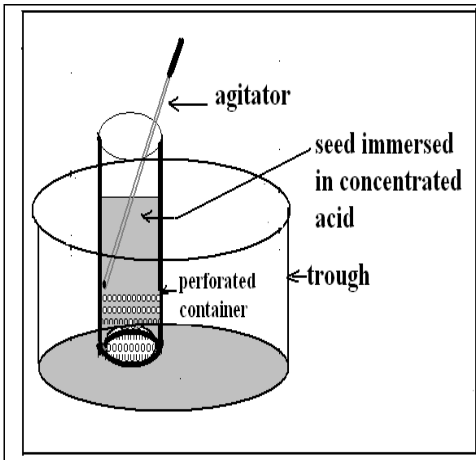


Figure 4. Scarifying seed by immersing in concentrated acid

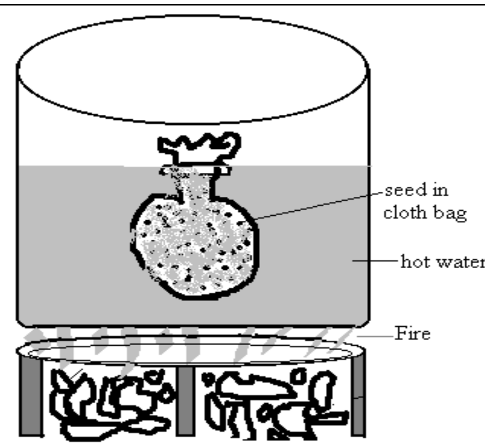
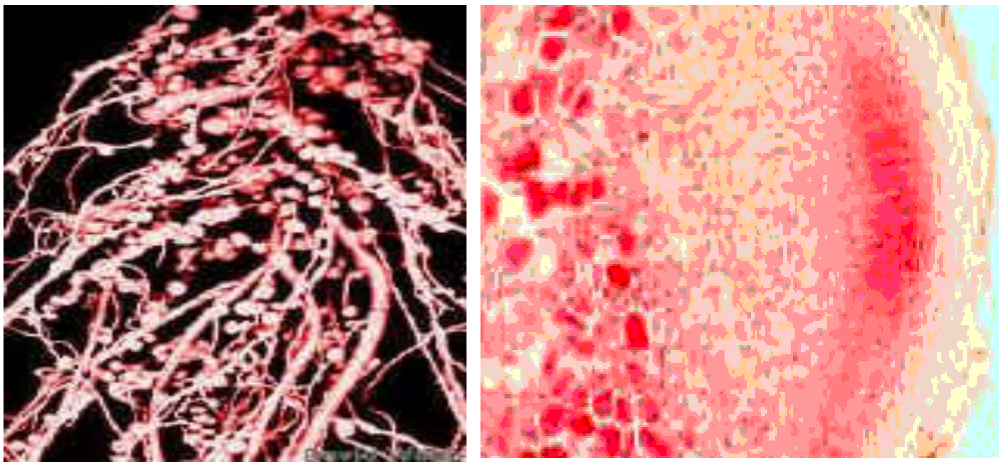


Figure 5. Scarifying seed by immersing in hot water

- **Inoculation:** Inoculation applies to legumes. Pasture legumes require the presence in the soil of a strain of nitrogen-fixing bacteria (*Rhizobium*) suited to an effective symbiosis. Some legumes are very specific in their *Rhizobium* strain demands. Inoculation is recommended particularly when introducing new species into new areas to ensure that the species are nodulated by the most effective and efficient *Rhizobium* bacteria strains. The culture is most commonly in the form of a black powder, but may also be a slope culture on agar gel, or rarely a freeze-dried culture.

Most native legume species do not require inoculation since they can be infected by bacteria strains living in the soil. Effective nodules should be pink inside but ineffective nodules are either white or green (Figure 7). It is recommended that the following procedures be used for inoculation:

- make a slurry of inoculant in water and mix the seed thoroughly to make all seeds wet.
- add a small quantity of sugar solution (10%) to the slurry to make it sticky. For inoculating 1 Kg of seed, a half teacup full of sugar is sufficient.
- Inoculation and drying should be done in the shade.
- Inoculated seeds should be sown within 24 hours after inoculation.



6a. A profusely-nodulated legume root 6b. Pink internal pigment
Figure 6. Profusely nodulating legume with internal pink pigment indicating efficient nitrogen fixation

- **Seed rate:** Seed rate depends primarily on the viability and purity of the seed. Furthermore, seed rate depends on seed size, desirability of a pure stand or mixture, amount of rainfall and soil fertility. As a general guideline, for row planting, sow grasses at 6-8 kg/ha, legumes at 3-4 kg/ha, and fodder shrubs 10-15 kg/ha. For broadcasting, sow at double the rate recommended for row planting.

Sowing practice

- ***Timing***. The best time is immediately before the season of the most reliable rainfall, and when temperature is favorable. Sow perennial species at the onset of the longest wet season when the soil has received sufficient moisture to support germination and establishment.

- ***Spacing***: Generally spacing between two rows should not exceed 25-45 cm and about 5-15 cm between two plants in the row.

- ***Depth***: Generally the smaller the seed the shallower the depth of planting. Usually, grasses are sown at the depth of 1-1.5 cm; while medium-sized legume seeds are sown at 2.5cm depth.

- ***Method of sowing***: There are two ways of sowing namely row sowing and broadcasting. Row sowing has the following advantages over broadcasting:
  - Low seed rate is required (seed economy).
  - Better establishment in case of poor weather conditions.
  - Easy weeding and fertilizer application
  - Better exposure of plants to sun light

When manually planting in rows, mark the rows with a stick or a row marker having adjustable spikes. Sow the seeds in the row and cover with a thin layer of soil and press the seeds into the soil by feet (men or animals).

When row planting is not possible (or not applicable), broadcasting is the other option. The sowing rate should be doubled to compensate for poor seedling survival. In covering surface sown seeds, driving animals back and forth, or dragging a spiny tree branch devoid of leaves, give good results.

4.3.2. Planting by vegetative parts

Vegetative propagation is necessary for establishing sterile plants, erratic-seeders and for plants giving seed of low genetic stability (hybrid varieties; segregating populations).

Methods

- ***Tuft splits***: tuft splits may be dug out by hand and taken to the establishment area and planted in furrows.

- ***Stem cuttings***: Ample soil moisture is necessary. Mature stems bearing three nodes are cut and planted in furrows or surface broadcast and covered with soil; two nodes buried and one left above ground. The spacing is 0.7 X 0.3 m inter-row and in the row respectively for runner grasses 2 X 2m spacing is recommended if weed control is adequate (Figure 7).

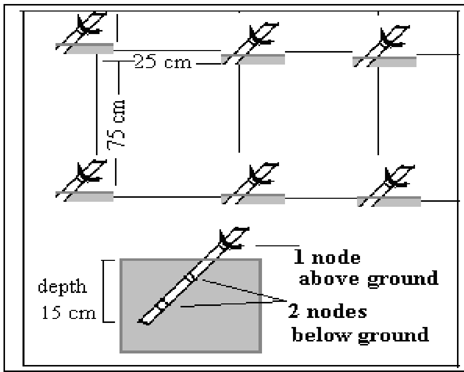


Figure 7. Vegetative (stem cutting) propagation of elephant grass.

Remarks: There are useful forage species like elephant grass and Kikuyu grass that must be propagated vegetatively by tuft splits or stem cuttings. For these crops, proper techniques must be followed for efficient multiplication of vegetative planting material, including packaging and distribution to growers. This is an important practice that contributes to availability of planting material.

4.3.3. Planting by seedlings

For browse trees and shrubs, it is advisable to raise seedlings some two months ahead of the rainy season using plastic bags in a nursery lat house. The procedures are:

Figure 8. Transplanting a seedling raised in plastic tube

- prepare a mixture of fine sand, forest soil and farmyard manure.
- mix well and moisten by sprinkling some water and filling plastic pots.
- Arrange the pots under a nursery shed and plant viable seeds (two seeds per hole if seed is not limiting)
- supply adequate water every day. Monitor germination and remove weeds.
- thin seedlings to one strong plant per pot.
- at the start of the rainy season dig out planting holes in the target field a week or so before planting to allow adequate water infiltration.
- preferably on a cloudy day, plant the seedlings in the prepared holes and return the topsoil followed by the subsoil and press firmly (Figure 8).

5. Husbandry of pasture seed crops

The overall aim of management, whether for grasses or legumes, is to produce high yield of quality seed. It involves manipulation of the local environment through management to meet the needs of particular crops.

5.1. Management of grasses

The primary aim in management of grass seed crops is to achieve dense tillers of similar age that subsequently produce seed heads. This can be achieved by two major practices namely defoliation by cutting or grazing and application of nitrogen fertilizer. These actions promote the development of many new tillers or shoots in the first few weeks of regrowth, leading to a more or less uniform flush of seed heads.

- ***Defoliation:*** A cleaning cut is accomplished by cutting or grazing at the beginning of each cropping cycle. A cleaning cut removes old vegetation and aids in the emergence of new tillers of nearly similar age. Recommended defoliation practices:
  - ➢ Perform a cleaning cut at the beginning of the growing season
  - ➢ The cleaning cut should not be below 10 cm stubble height so as not to discourage crop development
  - ➢ The cleaning cut of the seed plot should be completed within a few days to achieve a uniform stand

- ***Nitrogen fertilizer:*** A single application of nitrogen fertilizer stimulates maximum number of early tillers that produce the bulk of harvestable seed heads. For most grass crops, a safe application rate is suggested to be 220 kg urea per hectare, applied at the beginning of the crop cycle. Consider the following in Nitrogen fertilizer application:
  - should be applied as a single dressing soon after the cleaning cut,
  - Apply evenly to avoid unequal tiller development,
  - Farm yard manure (5 -10 t/ha) may be applied where financial resource is limited like the smallholder production system.

5.2. Management of forage legumes

The aim in developing a legume seed crop is to close the crop canopy at flower initiation to promote development of the necessary vegetative structure to maximize seed production. The following helpful practices are recommended:

Warm tropical legumes

- For warm tropical legumes, moisture stress is used to promote vigorous reproductive growth. This may be achieved through manipulation of crop canopy or irrigation frequency for irrigated seed crops
- Careful selection of seed production site with reliable and well-defined wet and dry seasons. A four- to six-month wet season is reported to favor development of strong vegetative framework for a heavy legume seed crop.

Subtropical legumes (clovers, medics, stylo)

- For subtropical legumes, strongly defined wet and dry seasons are less important because moisture stress has little or no beneficial effects on flowering.
- Such subtropical legumes need a period of adequate moisture, either from rainfall or irrigation, to provide the necessary vegetative framework for a seed crop.

5.3. Other helpful management practices for seed crops

5.3.1. Irrigation

- Irrigation ensures good seed yields in areas with unpredictable or low rainfall.
- In some crops, moisture stress can be used to stimulate the reproductive phase.
- For some legume crops (Siratro and Centro), alternating periods of irrigation and moisture stress in areas with a reliable dry season induces flushes of seeding.
- Overwatering may leach out soil nutrients care should, therefore, be taken

5.3.2. Pest and disease control

- Birds are the most damaging pests for grass seed crops
- Insect pests including moth caterpillars, sucking bugs and butterflies are more severe pests for legumes, often seen feeding on pods and flowers.
- E.g. Sesbania beetle (*Mesoplatis orchoptera*): the larvae devastate sesbania leaves
  Leucaena psyllid, a sucking insect, devastates *Leucaena leucocephala*.
- Diseases are generally more severe with legumes than with grasses.
- The more important legume diseases are rhizoctonia leaf blight, anthracnose in stylos, rust on Siratro and viruses on many species.
- Grasses suffer mostly from fungal diseases like ergots and smuts

- The best control is to grow resistant crops where the disease risk is high.

5.3.3. Weed control

Weeds reduce the yield of seed crops by competing for soil moisture, nutrients and sunlight and reduce seed quality by contamination with weed seeds. Production of high quality seed requires a weed-free crop. Growers should never rely on seed cleaning as a means of overcoming weed contamination. Weeds, especially broad-leaved ones can be dangerous, leading to partial or complete failure. Legume seed crops are particularly vulnerable to weed invasion. Some legume crops like vetch, lablab and desmodium form a vigorous canopy so weed control is easy.

Weed control measures

- Select sites with no history of dangerous weeds
- Exhaust soil seed bank through multiple light ploughs and allowing cycles of germination and subsequent destructions
- Grow a preceding crop with smothering power, e.g., vetch, lablab in areas where broad leaved weeds are common
- Hand weeding: early weeding is essential to remove competitive coarse weeds and speed up sward consolidation.
- Inter-row cultivation: use of hoes or sometimes by oxen as is common for maize crop cultivation (*shilshalo*)
- Cutting grass seed crops: done after the grass has established and before weeds flower
- Use of herbicides: selective and unselective herbicides
    - For broadleaf weeds use selective herbicides, e.g., 2,4-D in grass seed crops.
    - For grass weeds use pre-emergence or post emergence herbicides.

5.3.4. Trellising of climbing legumes

Trellising is providing supporting structures to climbing legumes so as to induce vigorous flowering and seed yield, and for easy and comfortable seed harvesting.

Advantages

- Increased seed yield; more than double the yield without trellising.
- Easier and more efficient seed harvesting.

Trellising materials

- **Sticks:** such as eucalyptus polls driven into the ground spaced one or more meters apart
- **Living trellises:** planting fodder trees such as sesbania in alternating rows with climbing legumes. Side branches have to be removed (as cut and carry fodder) to avoid shading
- **Wire fences:** efficient and last longer than other supports especially if treated posts are used, but expensive (Figure 9 and 10). The following specifications are recommended:
    - Height of posts, 2 meters
    - Spacing of posts in a row, 3 meters
    - Spacing between rows, 1-2 meters
    - Three to four reels of plain wire attached to the posts


Fig. 9 Trellising using sticks | Fig 10. Trellising using wire fence

6. Harvesting forage seeds

Efficient harvesting is decisive to the success of a seed enterprise. Harvest operations must be cautiously scheduled because it is common to encounter seed shattering in early maturing forage plants while a certain percentage of the stand is still flowering or starting to set seed. Generally, the period in which high yields of ripe seed can be harvested depends on the species or cultivar involved, weather conditions and harvest method.

6.1. Time of harvest

Scheduling the right harvesting time is difficult in grass seed crops. There is often variation in seed maturity in a particular crop species. Studies have indicated that the time at which maximum yield of quality grass seed is recovered is at a stage when the rate of increase of ripe seed balances the rate of seed shattering from older seed heads.

In many panicoid grasses, like *Panicum* and *Brachiaria*, up to 50 percent of mature or half-mature seeds shatter while still looking green while the rest are in the flower or early seed filling stage. Shattering early before an optimum time of harvest is also common in many forage legumes but fortunately fallen seeds can be swept up from the ground manually.

6.1.1. Some guidelines on how to judge ripeness

Grasses

- ***Ease of seed removal:*** Check that the bulk of seed is not far from shedding. At this stage, ripening seed can be readily removed by gentle rubbing in the palm of the hand or by stroking from the base to the apex of an inflorescence.

- ***Seed hardness (consistency):*** Check presence of seeds in florets by pressing the individual seed with a knife, or by biting with the teeth. Stage of seed development can be described successively as: “milky”, “creamy”, “cheesy” and “hard”.

- ***Field color (crop appearance):*** Observe for a change in crop color that depends on the pigmentation of individual seeds during maturation. In Rhodes grass, the crop goes from light brown to dark brown as the seeds mature. Brachiaria and Panicum are difficult genera to determine maturity by crop color because their seed stay dark green until full maturity. By then, the seeds have either been harvested by birds or fallen to the ground without being noticed by the attendant who is deceived by the green color.

Legumes

- ***Determinate plants:*** These are plants whose growth is terminated by flowering, thus with limited capacity for regrowth. E.g. *Desmodium* spp; *Stylo* spp. Optimum harvest dates can be approximated by examining the head from emergence through to seed shedding/shattering.

- ***Indeterminate plants***: Plants that are not terminated by flowering, retaining both floral and vegetative buds, thus with capacity to regrow and flower again, e.g. vetch; siratro. Indeterminate plants have longer flowering periods and fixing optimum time is difficult. Selective hand picking is the solution if the cost is not prohibitive.

In either type of legume crops, if hand sweeping of fallen seed is to be employed, harvesting should be delayed until most of the seed has fallen and there is little left on the standing crop.

6.2. Harvesting methods
6.2.1. Manual harvesting

- **Hand-harvesting (picking):** Hand harvesting is the simplest method and, where labor is cheap and plentiful, it is the most sensible to use. Grass seed heads may be cut with sickles, bound and stooked in the field, then collected for threshing some two weeks later. In rainy days, the sheaves have to be placed under an open shed. Heads may be beaten with sticks, roughly sieved and then dried under the shed. Only light threshing is required to detach most of the remaining useful seeds and to separate detached seeds from the bulk.

  A bunch of sheaves from the standing crop are tied up into bundles early before maturity to protect the seed from bird damage and to facilitate manual harvesting (Figures 11 and 12).

Figure 11. Tying seed head of Rhodes grass to facilitate manual harvesting of seed.

Figure 12. bundles of Rhodes grass cured under shed

The principal tools still used by small-scale farmers are sickles, knives, and scythes which are used to harvest the entire plant or, selectively remove seed heads.

- ***Knives:*** losses incurred from shattering are low, but labor requirements are higher
- ***Sickles:*** faster operation and less labor demand but shattering losses are relatively higher
- ***Scythes:*** Scythes consist of a 70-100 cm long curved blade connected to a two handled shaft. The blade requires frequent sharpening. To be effective, persons require training in the use of scythes but they can reduce sickle labor requirements by 25-30%.

- **Shaking:** Mature seed of both grasses and legumes are removed from the plant by shaking it into a basket or bag. Shaking and hand picking offer the advantage of leaving the remainder of the crop to ripen. Harvesting by shaking or by hand mowing along with the seed head is often facilitated by tying bunches of sheaves with soft string (Figure 12, above) early before shattering commences. In both methods, the shaking operation is suggested to be repeated three times a week.

- **Sweeping:** Sweeping is used to recover fallen seed from the ground. This operation applies for type of soils that can be readily separated from the seed by sieving. Cracking soils should be avoided. Soil particles of similar size as the particular seed cannot be removed by sieving. Instead, they are easily removed by a separator machine, seed blower, or by traditional methods (Section 6.4).

6.2.2. Mechanized harvesting

Use of harvesting machinery is an efficient operation but cost may be prohibitive. This option is mentioned here for larger scale commercial producers that may opt to go into the business of forage seed production.

- ***The reaper and binder machine:*** This mode of operation is analogous to the hand-harvesting of grass seeds and provided dry, still weather prevails, high yields of fair to good quality seed can be recovered because maturation continues in the slowly curing stooks.

- ***Line mower and header:*** Windrowing is an alternative in which grass or legume crops are mown and cured in the field for a few days before being picked up by a header. Higher yields of better quality seed are possible if dry weather prevails, but losses can be heavy if adverse conditions occur whilst the crop is curing in windrows.

6.3. Sweating

Sweating is the practice of holding freshly cut seed heads of tropical pasture grasses in covered heaps for periods of about three to four days before separating and drying the seed. While in the sweating heap the temperatures rises rapidly over the first day to a peak that often exceeds 50 ^{o}C, due to the respiration of the still metabolically active seed. Poor ventilation restricts gas exchange and spontaneous heating as high as 60 ^{o}C can occur. Both situations cause total seed death. Therefore, one has to frequently turnover the material to allow gas exchange and maintain temperature within safe limits. Figure 13 illustrates procedures of sweating.

Advantages:

- Allows marginally mature seeds to mature fully
- Easily detach seeds from seed heads (over 80% of pure seed detached within three days) enabling the producer to recover a higher proportion of the standing seed.
- It generally gives about twice the yield of direct-heading.
- Seed is of very high quality because maturation can be completed in the moist conditions inside the stack.
- Sweated seed stores very well.

Procedure:

- Hand cut with sickles
- Sheaves collected into bundles and placed on a canvas
- Sprinkle some water if sheaves are not moist enough to initiate heating
- Roll the canvas and place it under shed
- Allow the material to sweat for 3 to 4 days
- Turn over the sheaf every day to avoid overheating, and to allow gas exchange

a. Apply water to moisten dry sheaves	b. Roll in canvas to allow heating up	c. Place rolled sheaves under shed

Figure 13. Sweating fresh harvested *Brachiaria decumbens* seed crop

6.4. Threshing and cleaning

6.4.1. Manual threshing and cleaning: Where harvesting is done manually, as is the usual case for smallholders, the various labor intensive traditional seed cleaning techniques used for grain crops can be applied to forage crops which enable production of high quality seed with minimal post harvest loss. The collected material (sheaves of grasses and seed pods of legumes) should first be threshed manually by several ways: trampled by livestock or the material enclosed in a cotton bag or just spread on a canvas and beaten with a stick (Figure 14).

a) Beating seed head enclosed in cloth bag | b) Lightly beating harvested and cured seed heads

Figure 14. Hand threshing operations

The material may then be subjected to a series of indigenous cleaning techniques so as to separate the seed from chaff, weed seeds, or soil and sand particles. Most popular indigenous techniques applicable to forage seed crops are illustrated in Figures 15.

a) Winnowing | b) Separating soil and sand particles

Figure 15. Traditional seed cleaning techniques

6.4.2. Machine threshing and cleaning: Depending on the type of crop there are machines that perform reaping, threshing and cleaning operation simultaneously. Other machines harvest only and the threshing and cleaning operations are done by general purpose stationary machines that are equipped with adjustable parts to fit for different crops.

6.5. Drying, packaging and labelling

Seed drying is usually performed before cleaning by simply spreading the sheaf or partially threshed material on a canvas or cement floor under a shed. The seed is further dried to an acceptable moisture level to maintain its viability in storage. A seed moisture content of 8-10% is required to maintain good seed viability. Generally, for seed moisture levels above 8%, each 1% reduction in seed moisture content doubles the storage life.

After cleaning and drying, the seed is placed in a cloth bag (small quantity) or sisal sack (large quantity) and packed well. Durable packing is essential to facilitate safe keeping of seed during storage, transport and marketing. Plastic sacks should not be used as they prevent escape of water vapour.

Finally, each sack is labelled by attaching a durable tag or writing the label with permanent ink on the surface of the sack. At a minimum, the label should include the following information:

- Species/ Cultivar
- Date of harvest
- Location of harvest
- Weight
- Seed treatments (e.g., treated with fungicide, insecticide; scarified; etc)

7. Storage of seed

Environmental conditions in storage dictate the longevity of seed. Poor drying, packaging and storage is a primary cause of the failure in plantings of highly priced tropical seeds. Viability percentage is higher if the seed moisture content is low and storage temperatures are cool. For long term storage (5 years), seed should be stored at a low temperature (15 ^{o}C maximum) and low relative humidity (45% maximum). Each reduction of 5^{o}C in storage temperature doubles storage life. Storage index (measure of safety standard for storage conditions) is expressed as:

$$\{\textbf{Temperature } (^{o}\textbf{C}) + \textbf{Humidity } (\%)\}$$

There are recommended Storage Indices (SI) suggested for short, medium, and long term storage periods:

- Short term (0.5 year) SI 80 max
- Medium term (1.5 year) SI 70 max
- Long term (>5 years) SI 50 max

Grass seed is more vulnerable to poor environmental conditions than legume seeds that survive by means of their hard seed coats.

7.1. The seed store

A seed store should be well sealed, easy to clean, well ventilated, cool and dry. In warm environments, stores must be designed with roofs high enough, and tall walls with meshed ventilation slots so the inside day-temperature is kept as low as possible naturally. This design has proved to be an economical, small scale seed store for short to medium term storage without using air conditioners. Figure 16 illustrates such type of store designed for medium to low altitude areas.

Figure 16. Forage seed store, high-roofed with ventilation slots between the ceiling and the roof on all the four walls (DZARC)

7.2. Storage facilities and hygiene

Clean seed free from insects and properly dried (8 to 10% moisture for long term) can be stored on shelves (smaller quantities, e.g., <25 kg) or sacks (50 to 100kg) piled on wooden pallets to safeguard the seed from any moisture that might form on the floor.

Guidelines on storage hygiene:

- Regularly clean storage areas (e.g., weekly)
- Inspect incoming seed for pests and treat if infested
- Monitor the sacks for any build up of insects
- Apply insecticides (fumigants, dusts) to fight any threats of insect invasion

8. References

Alemayehu Mengistu and A. Robertson, 1989. Fourth Livestock Development Project contract forage seed production program: observations on first-year program. Proceedings of the 2nd National Livestock Improvement Conference, 24-26 Feb., 1988. Addis Ababa, Ethiopia.

Ferguson J.E. 1978. Systems of pasture seed production in Latin America. In: Sanchez P.A. and Tergas L.E. (eds), *Pasture Production in Acid Soils* of *the Tropics.* CIAT (Centro Internacional de Agricultura Tropicale), Cali, Colombia. pp. 413–426.

Humphreys L.R. and Riveros F. 1986. *Tropical Pasture Seed Production.* FAO Plant Protection and Production Paper 8. FAO (Food and Agriculture Organization of the United Nations), Rome, Italy. 203 pp.

Skerman, P.J., Cameron, D.G. and Riveros, F. 1998. Tropical forage legumes. 2nd Edition. FAO Plant Production and Protection Serious no 2. FAO, Rome.

Skerman, P.J. and F. Riveros, 1990. Tropical Grasses. FAO Plant Production and Protection Series No. 23. Rome, Italy. pp. 284-285.

ANNEX. Agronomic and seeding characteristics of common tropical and subtropical forage crops

1. Temperate perennial forage crops

1.1. Cocks foot (Orchard grass) *(Dactylis glomerata)*

Botanical description: Tufted perennial (Fig 17)
Adaptation: Highland adaptive, cold and frost tolerant.
- Altitude range: Highlands 2000 - 3000 m.a.s.l
- Climatic requirement: Rainfall 500-1500 mm. (mean annual), cold and frost tolerant.
- Soil requirement: Versatile in its soil requirement but does not tolerate water logging.

Cultivation: Requires well-prepared seed-bed
- Propagation: By seed, sown at the rate of 2 kg/ha
- Fertilizer requirement: Responds well to N and P application.

Utilization: Utilized mainly for mixed pastures.
Productivity: Up to 5-9 t/ha DM herbage.


Fig. 17. Cocks foot (*Dactylis glomerata*)

Seed crop management: Select well drained soil at medium to high altitude; Sow seed at 3-5 kg/ha early in the rains. Do not graze in the first year. In subsequent years, at the start of the rains cut to 10 cm high and fertilize with 100 kg N/ha (or farmyard manure, 5-10 t/ha). Cut seed head and thresh when seed is hard and ripe.
Reproduction and expected seed yield: Seed production up to 200 kg/ha.

1.2. White clover *(Trifolium repens)*
Botanical description: Trailing perennial legume up to 30 cm high (Fig 18)
Adaptation: Cool tropical highlands
- Altitude range: 1800-3000m
- Climatic requirement: Rainfall 700-1500mm
- Soil requirement: Versatile


Fig 18. White clover *(Trifolium repens)*

Productivity: About 1.5-2.5 t/ha DM herbage; good as grazing pasture for cool highlands.
Cultivation: Well-prepared seed bed
- Propagation: By seed at 2-6 kg/ha
- Fertilizer requirement: Responds well to P and S application

Seed crop management: Select a well-drained, non-acidic soil in areas above 2000meters altitude. Sow inoculated seed 2kg/ha in rows 30 cm apart for easy weeding. Do not graze in the first year; in later years, graze in the first month of the rainy season. Pollination by bees is essential for optimum seed setting. Seed will be ripe 4 weeks after

flowering. Cut and thresh when the seed is hard.
Reproduction and expected seed yield: Cross-pollinated; seed yield 100-400 kg/ha

2. Tropical perennial grasses
2.1. Buffel grass (Cenchrus ciliaris)

Botanical description: Tufted or spreading perennial grass 12-120 cm tall; has a large strong root system (Fig 19).
Adaptation: Adapted to semi-arid conditions; tolerant of drought.
- Altitude range: Sea-level to2000 meters.
- Climatic requirement: Rainfall 375-750 mm (does not do well in high rainfall areas but its rainfall requirement ranges widely: 300-1000 mm); temperature 20-30 ^{o}C; less cold tolerant than green panic.
- Soil requirement: Prefers light-textured soils of high P status, but still performs well on self-mulching soils; has only moderate tolerance to salt and water logging.

Cultivation: Light cultivation.
- Propagation: By seed at the rate of 6-8 kg/ha for drilling in rows and 12 kg/ha for broadcasting. Sowing depth is 1-2 cm; rolling or cattle trampling after sowing improves establishment.
- Fertilizer requirement: Responds to N application up to 160 kg/ha. “Buffel grass has a reputation as a phosphorus loving grass”.

Utilization: Good for grazing and hay making.
Productivity: Buffel grass is not a heavy producer and herbage yields usually range between 2 and 8 t DM/ha.
Seed crop management: Choose a well-drained soil at low altitude in a frost free area receiving above 400 mm rainfall. At the start of the growing season cut the crop to10 cm high and fertilize with 100 kg N/ha. Repeat after harvest to produce a second crop. Seed is ripe when seed can be readily stripped from seed head. Hand stripping will give higher yield than cutting and threshing whole crop.
Reproduction and expected seed yield: Apomictic; seed yield 40-100 kg/ha from each harvest.


Fig 19. Buffel grass *(Cenchrus ciliaris*)

2.2. Rhodes grass (Chloris gayana)

Botanical description: Stoloniferous perennial grass with the erect leafy stems up to 1.5 m bearing at the top 10-12 radiating brownish-green seed spikes (Fig 20).
Adaptation: Wide range of adaptation; moderate frost tolerance;
- Altitude range: 600-2200 meters above sea level.
- Climatic requirement: Rainfall 650-1200 mm
- Soil requirement: Versatile

Cultivation: Well-prepared seedbed. Propagation is by seed at the rate of 0.5-7 kg/ha depending upon amount of rainfall. Seeding depth should not deeper than 0.6-1.3 cm.

- Fertilizer requirement: Responds well to increasing levels of N application if in balance with P.

Productivity: Under farm conditions 5-8 t/ha DM; with high N application and variable cutting frequency yields up to 25 t/ha DM have been reported.

Fig 20. Rhodes grass (*Chloris gayana*)

Seed crop management: Choose a well-drained soil at medium altitude (1500-2200 m) area receiving above 600mm rainfall. At the start of the small rainy season cut the crop to10 cm high and fertilize with 100 kg N/ha. Repeat after each harvest to produce a second crop. Cut, sweat and thresh when most seed turn yellow and readily detach es from seed head.

Reproduction and expected seed yield: Cross-pollinated; isolation distance of 200 m is recommended in seed production. Seed yields 65-100-650 kg/ha, often two crops per year.

2.3. Guinea grass (Panicum maximum)

Botanical description: Tufted perennial with a shortly creeping rhizome; variable habit 60-200 cm high (Fig 21)

Adaptation: Adapted to low to medium altitudes from sea level-2000m

- Climatic requirement: Rainfall 780-1797mm (usually in excess of 1000 mm); temperature (optimum) 19-23oC; does not tolerate heavy frosts.
- Soil requirement: Versatile; more productive on fertile soils; tolerates acidity; does not tolerate both drought and water logging. (The tall cultivar, Hamil has medium tolerance to water logging)

Cultivation: Full seedbed preparation is required.

- Propagation: By seed at 3-6 Kg/ha; by sods spaced 0.6X1.25 m.; cuttings 15X45 cm. spacing.
- Fertilizer requirement: Responds well to N and P application.

Productivity: Up to 60.0 t/ha Dm when 300 Kg N/ha was applied (cv. Makueni)

Fig 21. Guinea grass (*Panicum maximum*)

Seed crop management: Choose a well-drained soil at medium altitude area receiving at least 900mm rainfall. Use seed rate 4kg/ha, in rows spaced 30 cm apart. At the start of the small rainy season cut the crop to10 cm high and fertilize with 100 kg N/ha. Repeat after each harvest to produce a second crop. When seed is able to be readily detach from seed head, cut seed heads, sweat, dry and thresh.

Reproduction and expected seed yield: Facultative apomict, with 1-5 % sexual reproduction. Seed yield 45-156 Kg/ha; harvest seed after 12-24 days from panicle emergence.

3. Tropical perennial forage legumes

3.1. Green leaf desmodium (Desmodium intortum)

Botanical characteristic: Vigorous perennial herb with ascending or creeping, branched reddish-brown stems (Fig 22)
Adaptation: Adapted to low and medium altitudes ranging 800-2500m. Best adapted to high rainfall areas exceeding 900 mm.
Herbage yield potential: Varies widely from 3-20 Dm/ha in pure stands
Cultivation:
- Propagation: by seed at the rate of 1-3 kg/ha in rows 45 cm wide. Green leaf is highly specific in its Rhizobium requirement.
- Fertilizer: Responds well to P and K application

Fig 22. Green leaf desmodium (*Desmodium intortum*)

Seed crop management: Early planting essential to allow crop maturity that is required for flowering, else seed setting delays up to the next season. Defoliation during the growing season enhances vegetative growth at the expense of seed. Trellising is helpful for healthy stand and easy seed harvest. Harvesting should be initiated when the seed has begun to turn brown and is hard. Allow seed to dry fully under shed and thresh using sticks or traditional mortar.
Reproduction and expected seed yield: self- and cross-pollinated; sensitive to photoperiod; it is a short day plant. Seed yields 300-500 kg/ha.

3.2. Perennial stylo (Cook stylo) (Stylosanthes guianensis)

Botanical characteristics: Erect or sub-erect perennial herb 30-120cm high (Fig 23)
Adaptation: Adapts medium altitudes up to 2000 meters. Grows best under warm climate; wide range of rainfall 600-700-2500 mm.; survives long dry periods; tolerates low pH of low P status due to endotrophic mycorhiza found in the roots.
Herbage yield potential: Varies widely from 2.5-10-15DM/ha (as pure). Good for over-sowing natural pasture.
Cultivation:
Propagation: By seed sown at the rate of 2-3 kg/ha. Sow seed in rows 75 cm apart for easy of weed control and management. Seed scarification essential by using one of the following methods:
- Mechanical scarification of seed using drum scarifiers.
- boiling for 10 seconds
- freezing to 17^{o}C for 7 days

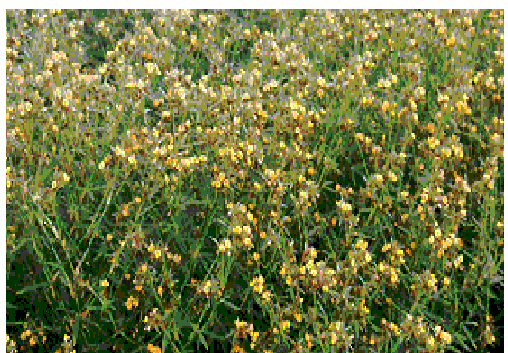


Fig 23. Common stylo (*Stylosanthes guianensis)* at full flowering

Inoculation is necessary for some cultivars with recommended *Rhizobium* strains.

Fertilizer: fertilizer P is needed on poor soils, normal rates are in the order of 50-100-150 kg super-phosphate/ha.

Seed crop management: Choose a well- drained site free of frost; remove weeds regularly by hand or use pre-emergent herbicides (treflan) at 2 lt/ha or post-emergent 2,4-D at 1 to 2 lt/ha; Flowering occurs over a longer period for cv Graham than Cook. Early planting allows seed harvest in the same year of sowing.

Reproduction and expected seed yield: Self-pollination but cross-pollination can occur. Expected seed yield is 300kg/ha from Cook and 600 kg/ha from Graham.

3.3. Axillaris (Macrotyloma axillare)

Botanical description: Twining perennial legume (Fig 24).

Adaptation: adapted to altitudes up to 2400 meters.

- climatic requirement: Best adapted to areas where rainfall exceeds 1000 mm; tolerant of drought but susceptible to frosting and water logging.
- soil requirement: Prefers light soil; tolerates soil acidity.

Fig 24. Axillaris (*Macrotyloma axillare*)

Site selection: Choose well-drained frost free site. Non-cracking soil is required to allow recovery of shattered seed using sweeping technique.

Cultivation: Light cultivation.

- Propagation: by seed at the rate of 3-5 kg/ha
- Fertilizer requirement: Responds well to N and P application.

Seed crop management: Self fertilized; flowers for more than a month if water is adequate; trellising is absolutely essential for this twining legume; pods shatter soon after ripening so collect seeds twice a week; shattered seeds should be swept up from the ground; seed yield vary from 150 to 500 kg/ha.

3.4. Forage peanut (Arachis pintoii)

Botanical description: a stoloniferous perennial legume with subteranian type of seed development (Fig 25).

Adaptation: adapted to low and medium altitudes to about 2200 meters.

- Climatic requirement: adapted to areas where rainfall exceeds 1000 mm; drought tolerant but intolerant of water logging and frost
- Soil requirement: Prefers well drained acidic soil.

Site selection: Choose frost free site with well-drained soil.

Cultivation: well-cultivation friable soil for easy penetration of fruiting organs.

- Propagation: by inoculated seed at the rate of 25 kg/ha 5 cm deep; sow in rows 50 to 75 cm apart early in the rains

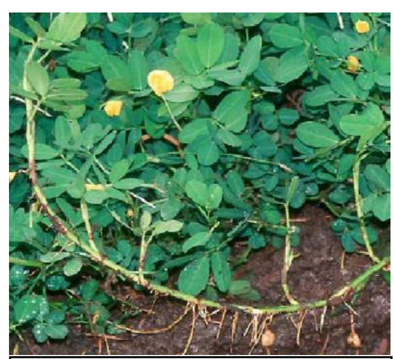


Fig 25. Forage peanut (*Arachis pintoii*)

Seed crop management: Regular weeding, manually or by using herbicides; flowers4 weeks after seedling emergence and continues throughout the season. Fruiting pegs penetrate the soil to a depth of 7 cm and form 1-3 nuts. Use hoes to dig out nuts as for food peanut.
Reproduction and expected seed yield: Seed yield is up to 400 kg/ha.

3.5. Alfalfa (Lucerne) (Medicago sativa)

Botanical Description: Perennial herbaceous legume (Figure 26)
Adaptation*:* Alfalfa adapts a wide range of environments and performs well at elevations from 1,000 to 2,500 m. Alfalfa can be grown almost anywhere in Ethiopia. It performs well at elevations from 1,000 to 2,500 m. It prefers deep, well drained loam soils. Poor drainage promotes root and crown diseases, inhibits nitrogen fixation, and reduces frost survival. Alfalfa tends t be sensitive to soil acidity. A soil pH between 6.5 and 8.0 is satisfactory for optimum forage production. It is relatively drought tolerant.
Cultivation*:* When grown as an intensive fodder crop (backyard / fodder bank), it is established near animal barns where there is better possibility of supplying irrigation and farmyard manure, and easy of feeding as green fodder. It is best established on well-prepared fine, firm seedbed. As pure stand fodder crop, seed rate is 10-14 – 20 kg/ha under irrigation and 6 – 12 kg/ha under rain-fed conditions (the lower rate for dry land environments).
Seed crop management: Select a ell-drained site from 1500=2400 meter elevation, rainfall above 800 mm. Surface sow seed at 8-10 kg/ha in rows to assist weeding. Avoid frequent cutting or grazing which damage the crown of the plant. Flowering is controlled by plant size, usually occurring 40 to 50 days after cutting. Pollination by bees is essential for optimum seed setting. For each hectare of alfalfa crop 5 hives have to be introduced. Harvest and thresh seed heads when seed is hard.
Reproduction and expected seed yield: Alfalfa is cross pollinated and tripping by bees is essential for seed production. Seed yield is in the range 200 to 600 kg/ha.

Figure 26. Alfalfa (Lucerne) (*Medicago sativa*) in early bloom ready for harvest

4. Fodder trees and shrubs
4.1. Tree lucerne, Tagasaste *(Chamaecytisus prolifer)*

Description: Tree Lucerne is a shrub or small tree (Figure 27). Useful as a multipurpose tree for cut-and-carry fodder, ornamental, windbreak, bee forage, fuel wood and biogas. It can be planted as a hedge and also has potential for alley-cropping systems.

Adaptation: Wide range of adaptation from low to 3200 m.a.s.l. altitude, the only browse legume adapted to higher altitude highlands of Ethiopia; can withstand frost as low as -9ºC. Tolerates infertile and acid soils and drought once established. Needs good drainage. Grows well on light, well-drained sandy

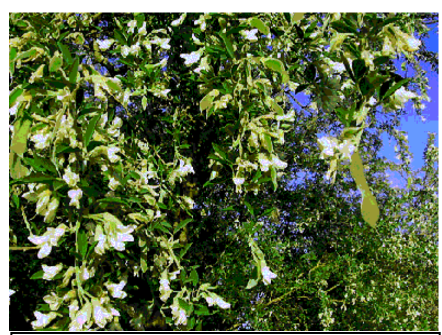


Figure 27. Tree lucerne (tagasaste) (*Chamaecytisus prolifer).*

soils on slopes and hillsides. It has a wide range of adaptability to soil pH (4.0–8.5).

Cultivation:

- Propagation is by seed sown directly or by transplantation. Spacing 30–50 cm between plants.
- Seed treatment necessary. Dip in boiling water for 5–10 minutes. Inoculate if possible.

Seed crop management: Select a well drained soil, at high altitudes where it performs best. Plants should not be cut below 1 meter height. Hand-harvest ripe pods before they shatter.

Reproduction and expected seed yield: Seed yield ranges from 100 to 300 kg/ha.

4.2. Desmanthus (*Desmanthus virgatus*)

Botanical description: a shrubby perennial legume (Fig 28).

Adaptation: adapted to low elevations up to 2400 meters.

- Climatic requirement: adapted to areas where rainfall exceeds 600 mm;drought tolerant but intolerant of water logging and frost
- Soil requirement: Prefers well drained soil.

Site selection: Choose frost free site with well-drained soil.

Cultivation: Light cultivation.

- Propagation: by seed at the rate of 2-4 kg/ha. Fresh seed is extremely hard-seeded and should be scarified, either abrasively (eg. using a rice polisher) or by hot water treatment (4-10 seconds in boiling water), to raise the germination to a minimum of 50-70%. Sow at the start of small rains

Figure 28. Desmanthus (*Desmanthus virgatus*)

Seed crop management: Desmanthus flowers late after the main rains; early seeding helps adjusting seed setting during favourable periods. Regularly-harvest individual ripe pods before they shatter.

Reproduction and expected seed yield: Seed yield is above 100 kg/ha.

4.3. Leucaena (Leucaena leucocephala)

Description: Leucaena is a long-lived shrub or tree up to 20 m high (Figure 29). It is a vigorous plant of high yield and high-quality protein; leaves and thin twigs well-accepted by livestock.

***Adaptation*:** Performs best under warm climate at low altitudes less than 2000 m, sensitive to frost, drought-tolerant, can grow at 400 mm annual mean rainfall.

- Altitude range: less than 2000 m.a.s.l.
- Soil requirement: Well-drained soils; not tolerant to acid soils; favours neutral-to-alkaline soils (pH 6.0).

Cultivation: Light cultivation for direct sowing; dug holes for transplanting.

- Propagation: by seed sown at 4–7 kg/ha, but

Figure 29. Leucaena (*Leucaena leucocephala*)

different rate or spacing can be used depending on utilization; sowing depth: 2–3 cm. usually planted by seedlings.

- Treatments: Seed treatment necessary. Hot-water treatment 60–80oC; H2SO4 for 10 minutes.
- Fertilizer requirement: On acid soils, liming may be necessary.

Productivity: Yields of 50 t/ha (cut at ground level) and 40 t/ha (at 75cm).

Seed crop management: Select a well drained soil, frost free site at low altitudes. For best seed production rainfall above 500 mm is required. Hand harvest ripe pods before they shatter.

Reproduction and expected seed yield: Seed yield is 100 to 500 kg/ha.

5. Root fodder crops

5.1. Fodder beet (Beta vulgaris)

Description: Fodder beet is an intensive root fodder crop usually grown by commercial dairy farms (Figure 30).

Adaptation**:** Adapted to wide range of altitude, mean annual rainfall above 800 mm, long growing season of four months or more, if not supplementary irrigation would be required.

Cultivation**:** It is planted preferably on fertile plot near animal corral where manure is deposited. It requires light soil with ample moisture. It is established from seed sown on ridges, spaced 40 by 75 cm, alternate tubers in the row thinned after half the growing season for early use, the remaining allowed to grow until the next season when tubers start to set reproductive organs provided that there is cold stimulation in that season.

Seed crop management: Fodder beet cannot be grown at low altitude zones for it requires cold temperature stimulation for bolting (flower setting). Therefore, one has to select a site at cool altitudes above 2600 meters. Plants should be allowed to grow over the next season when upon receiving cold stimulation the tubers produce flowering organs.

Figure 30. Fodder beet (*Beta vulgaris*)