

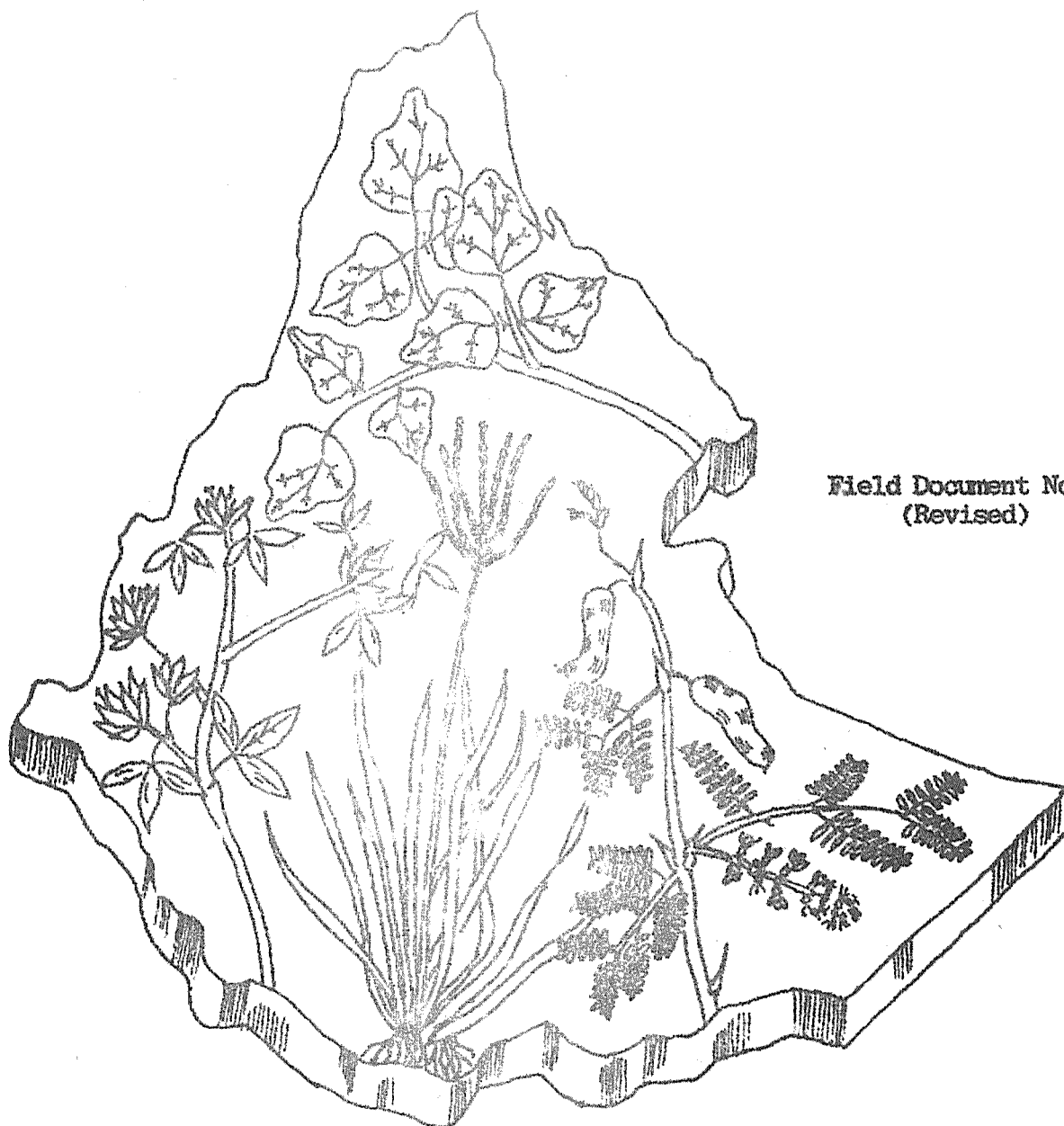


ASSISTANCE TO SOIL AND WATER CONSERVATION

PROGRAMME PHASE II ETH/81/003



# MULTIPURPOSE PLANT SPECIES FOR SOIL AND WATER CONSERVATION



Field Document No. 14  
(Revised)

BY  
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MINISTRY OF AGRICULTURE

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS  
ADDIS ABABA, ETHIOPIA

OCTOBER 1985

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1. FOREWORD

This field document is one of the series of documents scheduled under the project "Assistance to Soil and Water Conservation Programme - Phase II" (ETH/81/003).

Until recently, the revegetation activities of soil and water conservation were largely confined to the planting of fast growing tree species, mostly Eucalyptus. During the last two to three years, however, the benefits of multipurpose plant species for soil improvement, conservation and for meeting the needs of rural communities for fuelwood, fodder and timber have been greatly realised.

Several plant species of grasses, legumes, shrubs and trees, both indigenous and exotics have been tried in the nurseries and field planting.

Techniques of establishment and management of these plantations were hitherto not well understood by the technicians and extension agents in the field. This manual outlines the plant characteristics, requirements of site and climate, nursery and planting techniques and management requirements of some multipurpose plant species which have been successfully tried in Ethiopia. The list is however, not exhaustive. Trials are in progress with other plant species, which, if found suitable, will be added to this manual.

In this connection, the role of several indigenous species of fodder trees, grasses and legumes for forage production and soil conservation should not be ignored. These species being adapted to the local soil and environmental conditions need to be explored further.

This manual is primarily compiled for use by the field technicians and rural development agents who are directly involved in the implementation of the revegetation programme. This has been revised and two more species have been added.

It is hoped that the information contained in this manual will serve as a useful guide for the revegetation activities.

## 2.0. PRINCIPLES OF REVEGETATION

### 2.1. Background

For years the loss of soil and water has been adversely affecting the lives around the globe. It is now a well established fact that unrestricted removal of vegetation cover from the land is the most important factor encouraging soil and water erosion. The main factors responsible for degradation and loss of land are cutting of forests, overgrazing and inefficient farming techniques. Therefore, in order to restore and maintain these valuable resources, there is no alternative but to establish and maintain sufficient plant cover and follow efficient management techniques. In absence of proper and timely vegetation measures, physical conservation alone has little value.

While following a revegetation programme, consideration should be given to the desirable land use system and the requirement of the community living in that area. The plant species selected for revegetation should be able to meet the requirement of the community for food, fodder, fuel, timber and should generate rural industries etc. Thus the species should have multipurpose value. Special attention should be given to community forestry because, the products from this will be easily available to the people as & when required. Thus the plant species for revegetation programme should include forest, fodder shrubs, forage grasses & legumes and fruit trees. Selection of species for a particular area will largely depend on soil, climate and requirement of the people, however, obtaining desired plant cover remains the first priority.

In this publication notes on some forage grasses and legumes and fodder shrubs or trees are given which cover plant description, soil & climatic requirement, techniques of establishment and management, yield of herbage and seeds, diseases & pests and utilization. Although specific notes for plant species are given separately, a general note on establishment & management aspects under field condition is also given below.



## 2.2. Planting in the field

Generally, for soil & water conservation purposes, these species will be planted on eroded hillsides and grazing lands, on soil bunds, gullies, water ways and in agroforestry systems. It has been observed that planting of forest species is generally carried out as a monocrop at close spacing but it takes considerable period before a satisfactory plant cover is obtained & erosion hazards are reduced. It is suggested that wherever possible, forage species should be planted between the forest species which should be planted at slightly wider spacing than usual. These forage species will provide quick soil cover and also produce fodder for livestock at an early stage. Similarly, fruit trees & other useful plant species can also be planted on very steep hill sides which would not be grazed. The plant densities, however will have to be adjusted in all plantings for an optimum realization of soil protection and production benefits.

Choice of plant species therefore will depend on the following.

1. Suitable to soil and climatic conditions in the area.
2. Purpose of planting: soil and water conservation and producing food, fodder, fuel, timber etc.
3. Compatibility of species when planted in a mixed stand.
4. Should have good drought tolerance and resistant to diseases & pests.
5. Should be able to withstand some mismanagement.

## 2.3 Techniques of Establishment

### 2.3.1 Sources of planting material

Many plant species can be either planted with seeds or seedling or cuttings depending on efficiency of production of seed and its viability, and rate of growth at early stage etc.

#### 2.3.1.1. Planting with seeds

Those plants which produce a large quantity of good quality seeds and have fast growth following establishment, can be planted directly with seeds. Thus most of the forage species and some fodder trees can be easily established by directly sowing the seeds in the fields. However, their establishment will be influenced by factors such as quality of seed, land preparation, weather conditions, methods of planting etc. Planting details with seed are briefly described below.

##### 2.3.1.1.1 Land Preparation

Unlike many food grain crops, forage seeds are small in size and they need fine seed bed preparation before planting. The land should be cleared, cultivated properly and a firm, fine seed bed should be obtained, at least in the row where seed will be actually planted.

##### 2.3.1.1.2 Fertilization and Manuring

At present because of limited availability of fertilizer and manures and priority to food crops they are not available for applying to forage crops. However wherever possible, especially on infertile soils, organic manures at the rate of 5-10 tons/ha or about 100kg/ha of urea to grasses and about 50 kg /ha of DAP (Diammonium phosphete) is recommended for application at sowing. Application of nitrogen to legumes is not recommended as they fix atmospheric nitrogen under favourable environment.

##### 2.3.1.1.3 Methods of Planting

Forage crops can be established with seeds in two ways - by broadcasting or by row sowing or drilling in the soil. Establishment by row sowing should be preferred for the following reasons.

- a) In row sowing or drilling method, low seed rate per hectare is required. This is an important consideration when seed availability is limited.

- b) Row sowing gives better establishment than broadcasting specially when unfavourable weather conditions prevail after planting.
- c) Weeding and irrigation becomes easy and efficient.
- d) Row sowing gives better light penetration for good growth of the plant species.

Thus the above advantages of sowing outweigh the extra expenses incurred in sowing over broadcast method. However, where sowing cannot be done for practical reasons, broadcasting method should be followed.

It should be remembered that establishment of forage species especially perennial grasses is often difficult than many food crops and needs better seed bed preparation. Unlike annual crops if these species are properly managed, they will provide animal feed and soil cover for many years after planting. Normally, grasses are planted with forage legumes in a mixed sward which besides fixing nitrogen and improving soil fertility, provide high protein feed to animals. Many legume species however need seed scarification to break the hard seed coat and also inoculation with suitable rhizobium for nitrogen fixation.

#### 2.3.1.1.4 Seed Treatment

Sarification - There are various methods to scarify the seeds. For example, mechanical, acid treatment and hot water treatment. An easy and practical method is to treat the seed with hot water. The temperature and time to keep the seed in hot water depends on the hardness of the seed. For example, leucaena seeds are soaked in water heated to about 80°C for three to five minutes and then washed with cold water and dried. Alternatively, use less hot water and allow the water to cool with the seed.

### Inoculation

In order to get efficient nitrogen fixation by the legumes, it is necessary to inoculate some species with specific rhizobium. Effective nodule should be pink inside but ineffective nodules are either white or green. Simple method of inoculation is to make slurry of inoculant in water and mix the seed thoroughly to make all seed wet. A small quantity of gum arabica or sugar can be added to the slurry to make it sticky. For inoculating one kilogramme of seeds, half tea cup full of water, one tea spoon full of inoculant and one tea spoon full of gum arabica or sugar would be sufficient. Inoculation and drying of inoculated seeds should be done in the shade. Inoculated seed should be sown within 24 hours after inoculation.

#### 2.3.1.1.5 Seed rates

Seed rate/hectare will largely depend on seed size, purity and viability of seeds. Locally grown seed has no quality control and, therefore, slightly higher seed rates are recommended. Also higher seed rate is preferred to get quick soil cover to arrest erosion.

#### Seed Rates (Kg/ha) for Species Sown in Pure Swards

<u>Species</u>	<u>Sown</u>	<u>Broadcast</u>
Grasses	6 - 8	10 - 15
Legumes	3 - 4	6 - 8
Fodder Shrubs	10 - 15	15 - 20

This is a general guideline and more specific recommendation for various species is given separately. The above seedrates are applicable when these species are sown as mono crop and seedrate should be low when more than one species is established together in a mixed sward.

#### 2.3.1.1.6 Sowing of Seeds:-

Seeds should be sown during the longest wet season and when sufficient moisture in the soil has been received. Some time even dry sowing is also practised but it could be risky. Depending on the site of planting, e.g. closed areas, soil bunds or gullies etc. spacing of planting may vary but spacing between two rows should not be more than 25-40 cm and about 10-15 cm between two plants in the row.

Depth of planting is very important for forage seeds because of small seed size. The principle "smaller the seed shallower the depth of planting" should be observed. Generally 1.5 to 2.0 cm depth is optimum for most of the forage species.

When planted manually, rows are opened with a stick or crowbar at the desired spacing & seed is sown in the row. Seed is then covered with a thin layer of soil & pressed hard. In order to regulate the sowing especially of small size seeds, these are mixed with dry soil or sand to increase the volume.

Unless situation does not allow for row sowing, broadcasting of seeds should be discouraged, but when broadcasting is followed, seeds should be pressed hard to the soil. Depending on the extent of area this can be done by hands, feet or by trampling with animal feet.

#### 2.3.1.2 Planting with Seedlings

Generally, forest, fruit and some fodder shrubs or trees are planted with seedlings raised in the nurseries. Those plants which have slow growth rate and are prone to weed competition at early growth stage are established with seedlings. The details on the establishment & management of nurseries are given in field document no. 3 which should be read carefully for raising seedlings. Only the well grown healthy seedlings should be selected for field planting to get good result.

Equally good care should be taken in proper handling of the seedlings during transporting and planting in the field. Proper pitting and planting at right time at the start of the main rainy season when enough moisture in the soil have been received are important to obtain satisfactory results. These procedures become even more important with bare root seedlings. As stated earlier, to obtain quick soil cover and to meet the requirement of the farmers in the area it is advised that the tree species are planted with forage species.

Under unfavourable soil & climatic conditions, and on the steep hill sides, direct planting of forage seeds often gives very poor results and alternatively planting with nursery grown seedling generally gives very high rate of establishment. If facilities are available grass seedlings are raised in nurseries about 2-3 months before planting & then they are transplanted in the field. As compared to seeds, seedlings or cuttings (see below) are more resistant to adverse weather conditions. This also requires less seedrate as compared to direct planting.

#### 2.3.1.3 Planting with Cuttings

Those plants which do not produce or produce little viable seeds are generally, planted with root and stem cuttings, for example, elephant grass (Pennisetum purpureum) gives satisfactory establishment with cuttings. Similarly many forage grasses and some forage legumes can also be established with cuttings but planting with seeds should be preferred because planting with cuttings requires transport of bulk planting material. However, this source again gives more satisfactory established especially under unfavourable weather conditions. In order to get satisfactory establishment with root cuttings, while splitting the grass clump at least two living shoots should be included.

## 2.4 Planting Sites

### 2.4.1 Planting on Cultivated Lands

On soil bunds - These structures are very important on cultivated lands from the point of view of soil & water conservation. However, unless they are well stabilized, they are prone to breakings & damages thus requiring extra efforts to repair them and reducing their effectiveness. Therefore planting of suitable plant species during the first rainy season for proper stabilization is very important.

Before, planting, the bund tops & sides should be cleared off weeds etc. and if necessary reshaped (especially the old bunds). The soil where seeds will be planted should be well prepared. In order to obtain quick cover, it is recommended to plant at close spacing. For example, on the bund with about 50 cm width, two rows of grasses with one row of legume in between at a spacing of about 10 cm can be planted. To stop slipping off soil on the sides one row of grass can be established on the upper part of the slope on both sides of the bund. Wherever necessary, one row of a shrub e.g. pigeon pea (Cajanus cajan) could also be planted at the base of the bund on the front side. Procedure of planting with seeds as described earlier should be followed. Wherever possible, grasses can also be established with seedlings or cuttings.

### 2.4.2 In Cropping Systems

On cultivated lands, forage species are also planted as a part of cropping system. For example, in crop rotation, relay cropping, inter cropping, strip cropping, narrow grass strips etc. All these plantings directly or indirectly, have effect on soil and water conservation and also on improving fertility of the soil. For detail description of these procedures, please refer to Field Document No. 9 titled Some Farm Management Practices for Soil & Water Conservation.

#### 2.4.3 Gully Control

If the gully is excluded from human and livestock interference and depending on the extent of degradation, natural vegetation will regrow and stabilize the gully. However, this process can be hastened by planting fast growing species.

In order to stop further expansion of a gully, a thick stand of trees & shrubs should be established on the bank of the gully at about one metre distance from the gully bank. At the gully bottom, well grown seedlings or cuttings of grasses such as elephant grass should be planted with the care that flow of water is not obstructed. On the sides of the gully, seeds or seedlings of trailing type forage species should be planted. On steep slopes, a narrow platform should be prepared in the wall of the gully for planting seeds. Seeds of forage species should be sown as described earlier.

Vegetation should also be established just behind the check dams to arrest the flow of soil. Preferably, cuttings & seedlings of those species which could stant temporary water logging should be planted.

#### 2.4.4 Closed areas

A large area on steep hill sides and grazing lands which was badly eroded has been closed from human & livestock interference. It has started recovering but at a slow rate and with low forage production. To obtain fast recovery, to improve soil fertility & to get desired level of forage production in a short period after closing, it is suggested that, improved forage species especially the legumes and suitable fodder trees should be introduced on these areas.



Improved forage species should be sown in rows on the well cultivated strips having 2-3 meter width spaced at 10-15 meter apart. Seeds should be sown in the same way as on the soil bunds but at the spacing of 40-50 cm between two rows. Leguminous fodder trees can also be established in between the forage crop strips with nursery grown seedlings at a spacing of about one meter between plants & two meters between rows.

On too steep slopes, where grazing is not practical, fruit trees can be established in areas which are near the villages. These would be used by the villagers either for their consumption or for selling in the market.

#### 2.4.5 Water ways and other Sites

Water ways should be planted with trailing type grasses such as Kikiyu (Pennisetum clandestinum) or couch (Cynodon dactylon) which spread with stolens & also can stand temporary water logging. These species are generally planted with cuttings which give satisfactory establishment. These cuttings should be planted in loosened soil at a spacing of about 20 cm<sup>2</sup>.

Forage species and shrubs should also be planted to stabilize walls of ponds and earth dams. Similarly catchment areas also should be planted with the suitable species to reduce the rate of silting these structures.

#### 2.5 Management Techniques

The objective of establishing multipurpose plant species is to stabilize the physical structures where these species are planted and for utilization of the products from these species by the community to meet their requirements. The best results will however depend on the efficiency of management and proper management at early stage therefore, is especially important.

Although these species are established under various conditions, as described above, their management techniques, more or less are the same. For more details see the description on individual species.

#### 2.5.1 Forage species

Management of forage species includes both sown pastures and native pasture species. In case of sown pastures, one or two weedings may be necessary in the first year. This operation becomes difficult in crops sown by broadcast method as it is often difficult to note the difference between a crop and a weed plant at early stage of growth. In the first year, very light grazing or hand harvesting should be followed and forage species should be allowed to seed to ensure further regeneration. Although at present no fertilization is followed but annual application of at least about 100 kg/ha/year of nitrogen on pure grass and about 50 kg/ha/year of phosphorus to legume based pastures may be useful. Alternatively cattle manure or compost should be applied once a year at the rate of 5 to 10 tons/ha.

Harvesting of forage species is done by two methods (a) by cut & carry system & (b) by grazing by livestock.

Where it is not possible to allow grazing by livestock, for example, soil bunds on cultivated fields or very steep grazing lands etc and when controlled grazing can not be followed, it is best to cut the forage species by hand. Under hand harvesting, forage should be harvested at about 10 to 15 cm height and at or before flowering stage when maximum forage yield of high nutritive value is expected. Frequency of cutting, largely depends on the growth of forage species which is mainly influenced by weather conditions & soil fertility. Hand harvesting is safe so far maintaining sufficient soil cover is concerned but it is laborious & time consuming.

In case of grazing by livestock, it is very important to regulate the grazing pressure or number of livestock per unit area according to the availability of feed. At present the livestock population is very high and in absence of controlled grazing, it is very likely that these pastures will be quickly over grazed & the productivity of pasture and soil cover will be reduced thus again increasing the erosion hazards. Unless, grazing is regulated or controlled according to feed availability direct grazing should be discouraged.

#### 2.5.2 Fodder Shrubs and Trees

Weeds are often a serious problem during the early growth stages of these species. A weed free environment should therefore be assured by frequent weeding around the plants. Similarly, many species may be susceptible to insects and pests which should be kept under control by spraying with appropriate chemicals. This is even more important at the nursery stage. Although it may not be practical but it is not uncommon that these plants are watered in the fields during the unusual dry weather conditions specially those grown for seed production. However, to avoid this, it is strongly recommended to plant these species at the commencement of the long rains, so that plants are well established during the rainy season and become strong enough to withstand the harsh conditions in the dry period. In case of newly introduced species & planted for further multiplication, the above mentioned care is especially important.

If the above species are planted on grazing lands, grazing by cattle should be avoided till these plants are big enough. This can be achieved by following a zero grazing system. In case of fodder shrubs, it is important that they are not lopped in the first year and are allowed to establish well. At later stages they should be lopped for forage or fuel once a year or every two years, depending on their growth. However, about 10 to 15 per cent of top growth should be left on the plant. If these species are to be used for seed collection, they should not be lopped.

3. TECHNICAL GUIDELINES FOR MULTI-PURPOSE PLANT SPECIES

3.1 FORAGE GRASSES

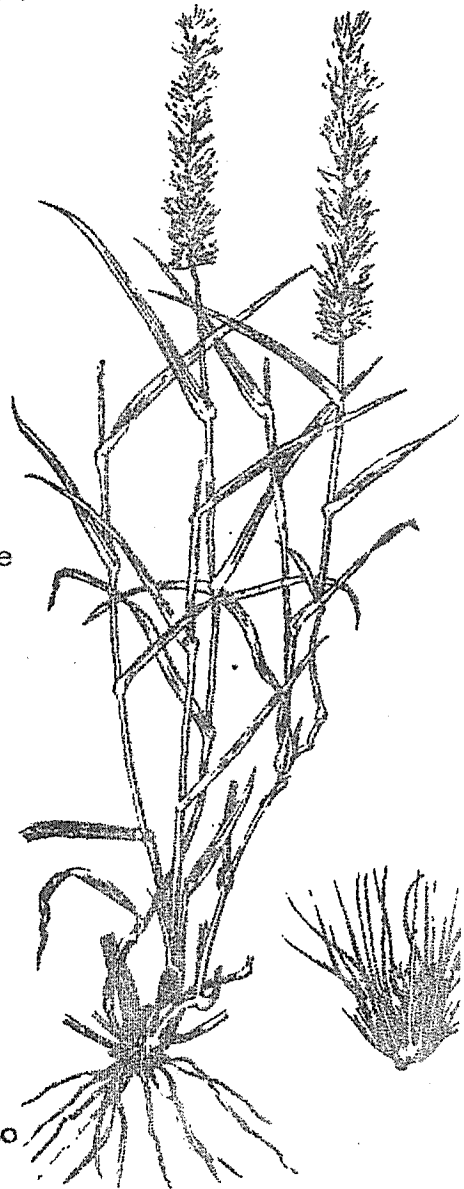
3.1.1 BUFFEL GRASS (*Cenchrus ciliaris*)

**PLANT DESCRIPTION**

Buffel grass is an erect or semi-erect deeprooted perennial, a native of Africa, India and Indonesia. The plant may grow upto 1.5 m. high when flowering. Buffel grass forms a strong culm with rhizomatous roots. It is drought resistant plant and stands heavy grazing. The leaves are glabrous, the inflorescence, a spikelike cylindrical panicle about 7 cm long on a peduncle. The spikelets occur in clusters of 1 to 3, they are pallid to red in colour and densely packed on rachis. Seed heads are straw coloured, the seed unit or fascicle comprises of a cluster of one to three spikelets enclosed in the involucre.

**SOIL REQUIREMENT**

Buffel grass is well suited to light textured sandy or self mulching soils which are free draining and are neutral to alkaline. It does not stand waterlogged soils. It is also moderately salt resistant.



### CLIMATIC REQUIREMENT

Buffel grass grows well in a warm climate with annual rainfall of 350 to 1,000 mm. It is not resistant to frost and it has high degree of drought resistance. It has shown good growth in many parts of Kenya and Ethiopia at lower altitudes under varying rainfall conditions. In buffel, a reduction to low temperature at 8°C reduced growth rate by 60 percent and further reduction to 4°C night temperature reduces growth rate by 90 percent. Suitable elevations for successful growth is up to 1,800 m.

### ESTABLISHMENT

Buffel grass can be established either with root cuttings or with seeds. When planted with seeds, thorough seed bed preparation is necessary to get satisfactory establishment. Well grown root cuttings can be satisfactorily established when planted with two to three active tillers.

Buffel seed is fluffy with bristles and when sown with a drilling machine, it should be mixed with sawdust. A seed rate of about five kg/ha of locally grown seed is suggested. As far as possible, broadcasting of seed on the cultivated land should be discouraged as it results in poor establishment. When planted as monocrop a plant spacing of 25 x 50 cm and when mixed with legumes a spacing of 50 x 50 cm. is suggested.

### FERTILIZATION

Buffel grass responds to nitrogen fertilization on poor soils. Annual application of about 50 to 100 kg/ha is recommended on poor soils, however, when sown with legume, application of phosphorus may be necessary.

#### WEEDING

One or two weedings may be necessary in the early growth period.

#### ASSOCIATION WITH LEGUMES

Buffel grass combines well with number of legumes such as siratro (Macroptilium atropurpureum) glycine (Glycine wightii) and stylos (Stylosanthes species).

#### HERBAGE YIELD

When buffel is grown for seed, the crop should not be harvested till seed maturity. When grown for forage, first harvest should be taken after three to four months, but before flowering. When harvested with hand it should be cut at 10 to 15 cm. above ground. Depending on the soil fertility 5 tons to 7 tons kg/ha of dry matter can be produced.

#### SEED PRODUCTION

Buffel grass flowers rather early but does not show exact climatic requirements for flowering. When matured, the seed can be easily pulled off the inflorescence. When most of the crop is ready for harvest, seed is manually harvested with long stems and left on the threshing floor for drying. About 100 to 150 kg/ha of good quality seed is harvested from multiple harvests. There are about 440,000 seeds per kilogramme. It should be noted that buffel seed has long rest period or dormancy of six to twelve months after harvesting.

#### DISEASE AND PESTS

The only diseases of buffel are ergot and smut which attack the spikelets, especially during the rains.

#### UTILIZATION

Suitable for forage production on poor soils and for soil and water conservation.

### 3.1.2 COLUMBUS GRASS (Sorghum aluum)

#### PLANT DESCRIPTION

Columbus grass is a short-lived perennial first found in Argentina. It is thought to be a natural hybrid between Sorghum helepense and Sorghum vulgare. It is a tall, robust, erect plant growing upto three meter high under good growing conditions. It spreads by short creeping rhizomes. Its stems are numerous, erect, solid and pithy, and the leaves are flat, broad and long and are glabrous. The inflorescence is a pyramid shaped panicle with branches in whorles with sessile spikelets, ovate and lanceolate. Glumes, brown or black completely cover the caryopsis at maturity. Caryopsis brownish in colour, ovate, 3.3 to 4 mm. long and 2 to 2.3 mm wide.

#### SOIL REQUIREMENT

Columbus grass grows on a variety of soils. The most suitable seems to be fertile, black alluvial soils but makes good growth on newly opened scrub soils in Australia. It can stand slightly saline soils but does not tolerate flooding. Being a strong grower, it has the reputation of exhausting soil fertility faster than other grasses.

#### CLIMATIC REQUIREMENT

Columbus grass grows successfully in warm and dry climate but can withstand certain degree of frost. It is a fairly drought resistant species and grows in areas receiving annual rainfall between 400 to 900 mm. In more humid areas, it may be susceptible to leaf diseases. In Ethiopia, it has been used on variety of soils but appears to be disappearing after two to three seasons of growth.



#### ESTABLISHMENT

Columbus grass is established with seed. The young seedlings of columbus grass are strong and force their way through the heavy soil crust. Seed is either broadcast or drilled. However, drilling gives higher establishment and needs less seed rate than for broadcasting. When sown, a row spacing of 80 to 100 cm. is adapted. Seed rate ranges from five to seven kg/ha for wide spaced rows and upto 20 kg/ha for broadcasting or close row planting.

#### FERTILIZATION

When grown in pure sward, application of nitrogen fertilization gives high yields and annual application upto 100 kg/N/ha can be used depending on soil fertility. High rates of fertilizer nitrogen can increase the HCN (Hydrocyanic acid) in herbage to a dangerous level.

#### WEEDING

Early weeding may be necessary, if weed competition is likely to be serious.

#### ASSOCIATION WITH LEGUMES

Legumes such as glycine (Glycine wightii) stylo (Stylosanthes species) vigna (Vigna species), and even lucern (Trifolium alexandrinum) can be grown with columbus grass though with varying success.

#### HERBAGE YIELD

When columbus grass is established for grazing, it should be grazed three to four months after sowing, when the plants reach a height of at least 30 cm. or more. However, early grazing should be avoided for the risk of HCN toxicity. When grown for hay or silage, it should be harvested at early flowering stage. Height of cutting should be about 15 to 20 cm. above ground. Columbus grass rapidly recovers after grazing or cutting and can give two to three harvests per season. Annual yields range from four to ten tons dry matter/ha. When grazed, heavy grazing should be avoided else its regrowth will be slow and poor.

#### SEED PRODUCTION

Seed setting differs in different cultivars, but it is generally satisfactory. Seed yield varies but a range of about 250 to 750 kg/ha in two harvests can be easily obtained. There is little or no seed loss during harvesting. Seed can be hand harvested at maturity. There are about 121,000 to 181,000 seeds per kilogramme.

#### DISEASE AND PESTS

Columbus grass is susceptible to the leaf diseases, Helminthosporium turcicum and Puccinia sp.

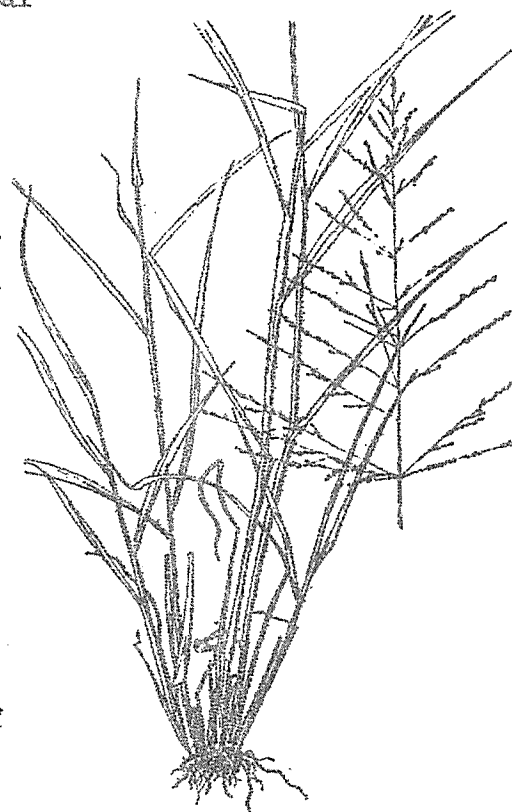
#### UTILIZATION

Columbus grass is usually used as a pioneer species on newly opened lands. It is also used for grazing or for forage conservation as hay or silage. It can also be used in soil conservation with varying success. Being a short term perennial grass, it is generally not recommended for planting on soil bunds.

### 3.1.3 GUINEA GRASS (Panicum maximum)

#### PLANT DESCRIPTION

Guinea grass is an erect bunch type perennial which is native of tropical and sup-tropical Africa. However, it has spread in most of the warm climate countries. Its root system is deep, dense, and fibrous which enables the plant to survive long droughts. It possesses creeping rhizomes and roots freely from stem nodes when comes in contact with moist soil. Its leaves are green, flat, long and tapering to a fine point. Leaf blades are hairy. The inflorescence is a large open panicle with lower branches tending to whorl. The spikelets are glabrous and flushed with purple and are two flowered. Commercial seed usually consists of the spikelets. The seed is about 2.25 to 2.50 mm. long, ellipsoidal and is straw coloured.



#### SOIL REQUIREMENT

Guinea grass is adapted to wide range of soil conditions. However, it grows better on well drained soil of medium to high fertility. Although it can be seen growing on poor soils but its growth is not satisfactory. It does not tolerate heavy clays or prolonged waterlogging or flooding. Short term flooding is tolerated only if the top parts of the plant is exposed to the air.

#### CLIMATIC REQUIREMENT

Guinea grass grows in warm frost free tropical climate. It tolerates shade and can be grown in tree plantations. Some varieties can grow in semi-arid tropics under an annual rainfall of 650 to 800 mm. but most types perform better in more humid areas with over 1,000 mm. of rain. Production is reduced due to low temperatures suitable altitude upto 2,000 m.

#### ESTABLISHMENT

Guinea grass can be established with root cuttings or with seeds but the later source is preferable. When planted with cuttings generally, two tiller cuttings are planted at 10 to 15 cm. deep at a plant spacing of 0.50 x 1 meter or 1 x 1 meter. Planting should be done during the long wet season when good rains have been received. For planting with seeds, a fine seed bed is essential. The seed should be sown on the onset of rains at the rate of four to ten kg/ha depending on its quality which is often low. The seed size is small and it should not be planted more than one to two centimeters deep. Mulching has been reported to be effective in improving establishment.

#### FERTILIZATION

Guinea grass responds to nitrogen fertilizers which improves its quality and yield. However, responses vary according to soil type and rainfall conditions. Although high responses to heavy doses of nitrogen are reported, a moderate annual application of 100 to 150 kg N/ha is suggested. Fertilizer should be applied in wet season in split application before sowing and after harvesting. When grown with legumes, application of phosphorus may be necessary on deficient soils.

#### WEEDING

Guinea grass establishment is slow and weedings in the first year are necessary. Weed control especially broad leaved weeds can be controlled with herbicides (2,4 -D etc.) but it is costly.

#### ASSOCIATION WITH LEGUMES

Guinea grass can be grown successfully with wide range of legumes. Depending on climatic conditions, legumes such as centro (Centrosema pubescens) kudzu (Pueraria phaseoloides) glycine (Glycine wightii) stylos (Stylosanthes spp.) silverleaf desmodium (Desmodium uncinatum) and siratro (Macroptilium atropurpureum) can be grown.

#### HERBAGE YIELD

If guinea grass is grown for seed production, it should not be harvested for forage after the rains. When used for forage, it can be harvested three to four months after establishment. When hand harvested, it should be cut at 10 to 15 cm. height and before flowering. Under grazing, controlled grazing must be practised for its longer persistence and higher yields. Yield of dry matter vary and upto 40 tons per hectare can be produced with heavy nitrogen. However, under average growing conditions, annual yield of about 10 tons/ha are easily obtained.

#### SEED PRODUCTION

Flowering in guinea grasses lasts over a long period and seed starts shedding before all the seeds mature on the inflorescence. Seed should be harvested when about 10 to 15 percent of seed shedding has occurred. Seed is hand harvested

and kept for few days for post harvest ripening before drying. Guinea grass seed has post harvest dormancy or rest period of 6 to 18 months. Seed yields vary and range from 50 to 150 kg/ha/year. There are about 0.7 to 1.5 million seeds in one kilogramme.

#### DISEASES AND PESTS

Guinea grasses are relatively free from leaf disease but some may be affected with Cercospora fusimaculosus, leaf-spot. The spikelets are often susceptible to fusarium or smut disease. Birds damage the seed crops when the seed is ripened.

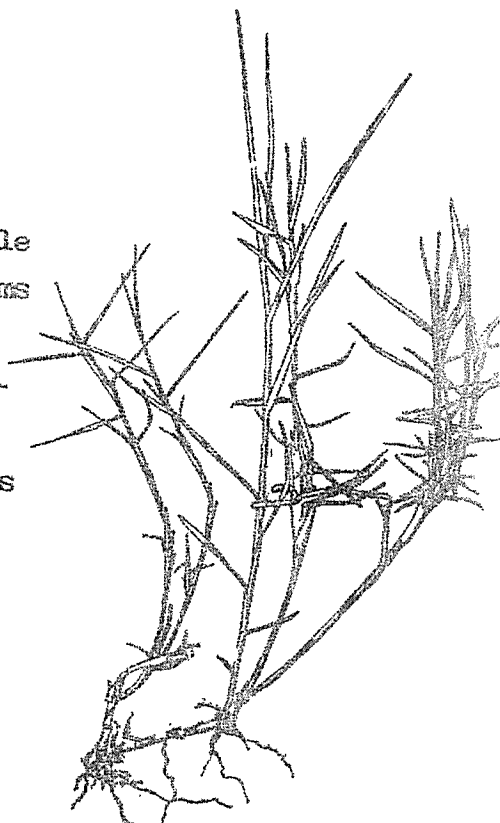
#### UTILIZATION

Guinea grass is a very suitable plant for soil conservation because of its spreading roots. It gives excellent feed as green or conserved forage for animal feeding.

3.1.4. KIKUYU GRASS (Pennisetum clandestinum)

PLANT DESCRIPTION

Kikuyu is a native of highlands and mountains of tropical East Africa where it occurs at altitudes ranging from 1,500 to 3,000 m. It is a creeping perennial with strong thick stolons and rhizomes which spread freely. It is a low growing deep rooted plant which forms a dense turf on the ground. Sterile upright shoots have relatively short stems and long leaves. Fertile shoots which terminate in flowering heads do not exceed the sterile shoots in height, but are usually hidden beneath the sterile shoots at the bottom of the sward. It produces fertile shoots and flowers when it is closely grazed or mown. The spikelets are supported by a few to fifteen slender bristles which are shorter than the spikelet.



SOIL REQUIREMENT

Kikuyu grass requires fertile soil and is tolerant to high soil acidity. Freshly opened land is quickly colonised by kikuyu grass. When soil fertility reduces, kikuyu grass vigour and growth are also reduced and at the end it could be completely replaced by other grasses. It does not grow under waterlogged conditions.



#### CLIMATIC REQUIREMENT

Kikuyu grass grows well on high altitudes in cooler environment. It is more cold tolerant and makes good growth in winters if nitrogen supply is adequate. Kikuyu grass needs high moisture in the soil and grows between the range of 1,000 to 1,600 mm annual rainfall, but may not grow well below 900 mm rainfall. Because of its deep root, it is able to extract moisture from the deeper soil layers.

#### ESTABLISHMENT

Generally, kikuyu grass is established with cuttings which give satisfactory establishment. It can also be established with seed but seed is not easily available (except in Australia) and it is very costly. The cuttings either can be planted with hand or spread with machine and harrowed. Plant spacing when hand planted can be about 50 x 50 cm. but closer spacing is advised for quick cover of the ground. Assured rain is important for successful establishment. Seed can be drilled in soil but it should be mixed with inert material since the seed is very small in size. Once established, it colonizes the area very quickly and it could become nuisance in the cultivated lands, if not properly controlled. When planted with seeds, seedrate of 3-6 kg/ha is normally used.

#### FERTILIZATION

Kikuyu grass responds to heavy nitrogen fertilization which increases its yield and feed value. Annual fertilization, especially with nitrogen is necessary for its best performance. A moderate rate of 200 -250 kg N/ha can be recommended under grazing. It may also need other nutrients if the soil is deficient in them.

#### WEEDING

Generally, no weeding is required as the kikuyu spreads fast and smothers other species.

#### ASSOCIATION WITH LEGUMES

Kikuyu is a strong and aggressive plant and if provided good growing conditions, does not allow other species to grow satisfactorily. However, under heavy grazing or repeated cuttings, Kenya white clover (Trifolium semipilosum) has been grown but legume often disappears, once grass growth is vigorous. Clover (Trifolium species) and desmodium (Desmodium sp.) are also reported to be growing with kikuyu.

#### HERBAGE YIELD

Depending on the soil and climatic conditions dry matter yields of 10 to 15 tons/ha have been reported. When fertilized with nitrogen, it makes excellent feed for dairy animals. Generally, for more efficient utilization, it is grazed rather than being managed under cut and carry system.

#### SEED PRODUCTION

Seed can be produced, but with difficulty. Generally, fertile shoots are close to the ground and for harvesting seed, the grass stand has to be heavily grazed or mown. Seed is difficult to harvest and clean. It has high germination percentage. The seed has few months dormancy period. There are about 4,000,000 seeds per kilogramme. Seed yields of 480 kg/ha were reported in Australia.

#### PEST AND DISEASES

Kikuyu may be attacked by Prosopia distanti.

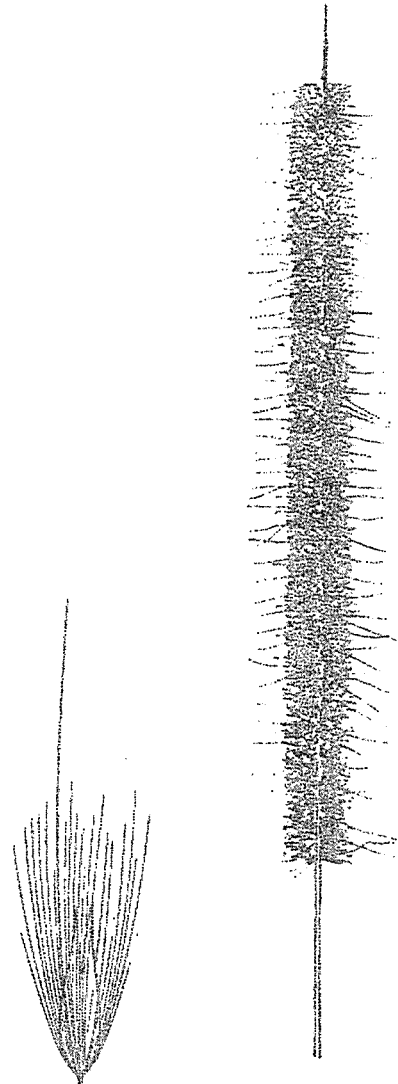
#### UTILIZATION

Kikuyu is an excellent feed for high producing animals. It is generally grazed and not conserved as it has high moisture content. It is the best grass for soil and water conservation on steep lands. It forms a dense mat and soil losses are reduced to minimum.

### 3.1.5 NAPIER GRASS (Pennisetum purpureum)

#### PLANT DESCRIPTION

Napier grass which is also called elephant grass due to its tallness and vigorous growth is a native of tropical Africa. It is a robust perennial, forming large culms spreading by stem base, rooting from nodes or by short rhizomes. Stems are erect, branching in the upper part, with upto 20 nodes, two to six meter tall. Leaf sheath is glabrous or hairy. Inflorescence, a panicle, spike-like dense cylindrical 10 to 30 cm. long and 15 to 30 mm wide of varying colours with a densely hairy rachis. Spikelets five to seven mm. long, solitary or in clusters of two to five, of which usually only one is fertile. Elephant grass is valued for its high herbage yield, competitive vigour and persistence, high palatability and good herbage quality.



#### SOIL REQUIREMENT

Napier grass grows on a variety of soils but prefers heavy fertile soil with high nitrogen. It requires well drained soils and does not tolerate waterlogging conditions and flooding. In Ethiopia, it has shown satisfactory growth on variety of soils. The pH limits are between 6.5 to 8.0.

#### CLIMATIC REQUIREMENT

Napier grass is grown best in warm climate with high rainfall conditions. However, it tolerates low temperature fairly well but does not tolerate frost conditions. Rainfall of about 800 to 1,000 mm or over and temperature 24 to 28°C are more suitable. It is drought resistant but not for prolonged periods, without affecting its yield.

#### ESTABLISHMENT

Napier grass produces little or no viable seed and generally it is planted vegetatively with root or stem cuttings which form a bulky planting material. The land should be thoroughly prepared by ploughing or harrowing before the rains. In spot planting the soil should be dug 10 to 15 cm. deep and made soft for inserting the cuttings. About five to six month old stand of napier grass should be used for obtaining planting material. Cuttings should have two to three active buds. These cuttings should be planted in the prepared seed bed when good rains are received in the main rainy season. While planting, one or two nodes at the basal end of the cutting should be buried in the soil at about 45° angle and the soil should be pressed hard around the cutting. On flat land when planted in rows, the spacing vary from 30 x 50 cm. to 60 x 60 cm. depending on soil and rainfall conditions. Napier grass can also be planted like sugarcane if machinery is available.

#### FERTILIZATION

Napier grass grows best on fertile soil and responds to organic manure and application of nitrogen. Under favourable environment, annual application of upto 200 kg. N/ha has been recommended. Nitrogen should be applied in split doses after each cut. If necessary, phosphorus and potash should also be applied once in a year in the beginning of the wet season.

#### WEEDING

Napier grass is slow in growth in the beginning and needs frequent weeding when weeds are a problem.

#### ASSOCIATION WITH LEGUMES

Napier grass is usually grown in pure stands but legumes can also be successfully grown if properly managed. Legumes such as pueru (*Peuraria phaseoloides*) centro (*Centrosema pubescens*) and desmodium (*Desmodium species*) combine and grow well.

#### HERBAGE YIELD

Napier grass can be used for grazing or for conservation as silage. When grazed, the plants should not be allowed to grow over 100 to 120 cm. tall in height and for cutting, over 200 cm. tall else older growth becomes stemy, coarse and less palatable. Interval of cutting varies from four to ten weeks, depending on growth conditions. Cutting height in the beginning is about 15 to 20 cm. but this is increased with time, because of the presence of old stumps. After every one or two years, it is recommended that all the old growth should be removed. Yield of herbage vary and could be from 15 to 30 tons per hectare. Still higher upto 80 tons/ha can be exploited under intensive management conditions, i.e. under irrigation and heavy fertilization.

#### SEED PRODUCTION

Seed setting in napier grass varies and usually it is poor. However, good seed formation has been reported from Australia. The seed produced did not show post harvest dormancy. Seed is fluffy and needs processing. There are about three

million spikelets of seeds in one kilogramme. Elsewhere, seed is not easily available and vegetative propagation is more reliable method of establishment.

#### DISEASES AND PESTS

Helminthosporium ocillum fungus causes serious leaf spot disease.

#### UTILIZATION

Napier grass gives very nutritious feed when fed as fresh green or conserved forage in the form of silage. It has proved very effective for gully control because of its fast and robust growth.

3.1.6 PHALARIS (Phalaris aquatica)

PLANT DESCRIPTION

Phalaris is a native of Southern Europe and the Mediterranean region. It is a deep rooted tufted perennial with tall erect culms and spreads by loosely branched rhizomes which grow outward for a short distance from underneath older parts of the rootstock, before ascending vertically and giving rise to a tuft of well spaced tillers. The leaves arise mainly from the base but also develop from higher nodes as the flowering stems elongate. Both leaf sheaths and blades are glabrous and bluish green. Flowering culms are erect, glaucous, stout and hard when mature. Inflorescence a dense compact oblong to cylindrical panicle 5 - 12.5 cm. long and 13 mm. wide. Spikelets laterally flattened, 5 - 7 mm. long, one flowered with two large boat shaped glumes which are almost equal. The seed is cream to pale brown, smooth and shiny, narrow ovate to lanceolate, laterally compressed, about 3.25 mm. long and consists of the caryopsis with fertile lemma attached and the remnants of the sterile lemmas.





#### SOIL REQUIREMENT

It is adapted to wide range of soils in the higher rainfall areas but does best on heavier textured soils and responds to high levels of soil fertility. Under low rainfall conditions, soil type becomes critical, especially in determining persistence and vigor. Adapted to soil pH ranges of 4.9 to 8.2 but does not like saline soils.

#### CLIMATIC REQUIREMENTS

It is adapted to a mediterranean type of climate of mild moist winter and hot and dry summer and particularly useful within a rainfall range of 430 to 630 mm. It is extremely drought resistant and also withstands water logging. Adapted to elevations above 2,800 mm. in tropics where cool temperatures prevail most of the year.

#### ESTABLISHMENT

Phalaris can be established with seed but the seedling growth is slow. It is sensitive to competition for light. The soil should be cultivated to obtain fine seed bed and seed should be drilled at the rate of 6 to 10 kg/ha. On soil bunds, on the cultivated lands, it can be planted manually in rows at a spacing of about 50 cm. in rows and 20 cm. between plants. The seed should be covered and pressed well in the soil. As for other grasses, planting should be done when good rains have been received.

#### FERTILIZATION

Phalaris responds to fertilization and when sown in pure swards, nitrogen application of about 100 - 200 kg/ha/year in split doses can be applied especially for crops grown for forage conservation.

#### WEEDING

As initial growth of phalaris being slow, one or two weedings are suggested during early stage of growth.

#### ASSOCIATION WITH LEGUMES

Because of plant competition, it is generally not sown with other grasses. However, legumes such as alfalfa and clover can be sown with phalaris provided effects of competition are controlled by optimum grazing pressure.

#### HERBAGE YIELD

Phalaris can be used both for grazing and for forage conservation as hay and silage. Cutting at a height of 10 - 15 cm. gives higher rate of regrowth and higher yield of herbage than when cut too low and too frequently. For forage conservation, it should be cut when first flowering shoots are observed in the field. Yields upto 13 - 15 tons/ha of dry matter has been reported when cut for hay making. However, yields largely depend on rainfall and soil fertility conditions.

#### SEED PRODUCTION

Phalaris produces good quality seed. Seed matures from top of the inflorescence downward. Matured seed shatters and therefore it should be harvested when 40-50% of the seed has changed colour to dark grey or brown. Swathing has been reported to help in seed maturity. For seed production, it should be planted in rows at 90 cm. apart. Seed is harvested either with machines or hand. There are about 880,000 seeds per kilogramme.

#### DISEASES AND PESTS

Phalaris is fairly free from major diseases and pests. Occasionally, however, grasshoppers and cut worms are a problem. Leaf diseases are caused by Helminthosporium giganteum.

#### UTILIZATION

Phalaris has been found suitable for soil conservation, maintenance of waterways and stream channel banks. It also provides good livestock feed both in fresh and conserved forms.

### 3.1.7 RHODES GRASS (Chloris gayana)

#### PLANT DESCRIPTION

Rhodes grass is a tufted, perennial, native of Southeast Africa. It forms a large culm and spreads with stolons. It profusely tillers and grow upto 1.5 meter height. It develops a vigorous root system which gives it an appreciable degree for drought resistance and makes it suitable for control of soil erosion. The leaves are smooth, dark green and upto 45 cm. long. Inflorescence is a digitate panicle consisting of 8 to 12 one sided sessile spikes clustered on the apex of the rachis. Seeds consist of two florets one of which is infertile.



#### SOIL REQUIREMENT

Rhodes grass is a quite versatile in its soil requirement. However, the heavy clay are not suitable. It develops particularly well on soils of loose texture such as volcanic ash and that is why, probably, it grows so well in many parts of Ethiopia. It is tolerant of alkaline and saline soil conditions but does not tolerate soil acidity. It withstands waterlogging, but for a short period only.

## SEED PRODUCTION

Rhodes produces good quality seed but seed yield largely depends on growing conditions. Seed should be harvested when the inflorescence starts drying and changes its colour to ashy brown. In tropics under irrigation, two to three crops per year can be harvested. Seed yields range from 100 to 300 kg/ha. There are about two million seeds per kilogramme. Rhodes grass seeds have no dormancy but germination percentage improves after few months of storage under ideal conditions.

## DISEASE AND PESTS

Rhodes grass may be affected from *Helminthosporium* leaf spots causing die-back of leaves. It may also be affected by scales (*Antonina graminis*) and thrips (*Chirothrips mexicana*).

## UTILIZATION

Rhodes grass is a good pioneer grass on newly opened lands. It has been an effective plant in soil and water conservation. Rhodes grass produces good quality herbage for animals which could be fed fresh green or conserved as hay or silage.

### 3.1.8 SETARIA GRASS (Setaria anceps)

#### PLANT DESCRIPTION

Setaria grass is a native of tropical Africa occurring north of South Africa, to Kenya and Senegal. It is a tufted perennial, stems erect, sometimes with ascending base, one to two meter high, moderately thick and usually compressed in the lower part. The leaves are upto 40 cm. long and 8 to 20 mm. wide, glabrous and lightly compressed. The inflorescence is a panicle which is cylindrical and 10 to 20 cm. long. Spikelets, 2.5 to 3 mm. long, are elliptic and flat.



#### SOIL REQUIREMENT

Setaria occurs on a variety of soils except those of high alkalinity or acidity. It requires well drained soils but tolerates temporary flooding and waterlogging. It is also resistant to fire. Setaria, however, responds to improved soil fertility conditions.

#### CLIMATIC REQUIREMENT

Setaria is essentially a summer growing plant but has good cold tolerance in the winter. It grows in a rainfall range of 500 to 700 mm. It cannot survive long dry season. It grows on high altitudes ranging from 600 to 2,600 m. Setaria can tolerate light frost but top growth may be affected.

#### ESTABLISHMENT

Setaria can be established vegetatively or from seeds. It can be planted with cuttings which sprout easily and give satisfactory establishment. When planted with cuttings, it should be planted at 10 to 15 cm. deep and at a row spacing of about 0.5 m x 1 m, in well prepared soil. However, large scale establishment is generally done with sowing of seeds. A thorough fine compact seed bed is essential. Seed should be sown at a depth of 1 to 2 centimeters in rows, 50 to 100 cm. apart. Depending on quality, a seed rate of five to ten kg/ha is recommended. Setaria can also be established under maize. Seed is often broadcast when maize reaches a height of 80 to 100 cm.

#### FERTILIZATION

Setaria responds well to fertilization. If soils are poor, nitrogen application at sowing and at subsequent harvests is recommended. Setaria is more sensitive to nutrient deficiencies, for example, phosphorus and sulphur. Annually, 100 to 150 kg N/ha should be applied for a pure crop or when grown for seed.

#### WEEDING

Early growth being very slow, two to three weedings in the first year may be necessary

#### ASSOCIATION WITH LEGUMES

Setaria combines well with many pasture legumes. Mixtures with desmodium (Desmodium species) siratro (Macroptilium atropurpureum) glycine (Glycine wightii) stylos (Stylosanthis species) lotononis (Lotononis bainesii) have been successfully grown. In Kenya, it has also been grown with Trifolium repens.

#### HERBAGE YIELD

Setaria can be harvested for feeding animals in the first year of establishment. For this, it should be harvested at a height of about 10 to 15 cm. from ground level and before flowering. Setaria tillers profusely and gives high yield of forage if properly managed. Yield of dry matter under cutting has been high upto about 30 tons/ha with nitrogen fertilization. However, yields of five to ten tons/ha/year are common under average growing conditions.

#### SEED PRODUCTION

Setaria continues flowering over a long period and it is difficult to harvest all the seed crop at a time. If harvesting is delayed, seed shedding takes place. In order to get maximum quantity of seed, matured seed heads should be selectively hand harvested when about 10 to 15 percent seed shedding has taken place. Harvested crop can be left in open in thin layers after harvesting for post harvest ripening. Average seed yields from two harvest per year range from 100 to 200 kg/ha.

#### DISEASES AND PESTS

Leaf diseases are not common although Pyricularia tirsae which causes red spots on the leaves is common in some places. Inflorescence is affected by Sphacetotheca and Fusarium nivale. Seed crops can also be ruined by Tilletia echinosperma known as setaria bunt. Occasionally, setaria may be damaged by army worms. Seed is also damaged by birds.



UTILIZATION

As a forage in green or conserved form, satisfactory silage can be made but addition of molasses is necessary. It is suitable for soil and water conservation and for stabilization of soil bunds on the hills in cooler areas.

### 3.2 FORAGE LEGUMES

#### 3.2.1 CARRIBEAN STYLO (Stylosanthis hamata)

##### PLANT DESCRIPTION

Carribbean stylo is a short lived perennial legume native to the West Indies and the lands which border Carribbean Sea. The cultivar VARANO was collected from Northern Venezuela. It is a non-determinate plant with a semi-erect habit and a branching pattern which is often dichotomous.

The stems have short white hair down one side. Leaves trifoliate, leaflets lanceolate, acute, glabrous with four to six pairs of veins and the bidentate stipules adnate to an oblong spike with 8 - 14 flowers on a long stem. The seeds are medium to dark brown in colour, 2 - 2.5 mm. long,

unsymmetrically reniform, radical ends fairly prominent. Varano has better drought tolerance than Townsville stylo which is now seriously affected by anthracnose disease.



##### SOIL REQUIREMENT

Varano is adapted to wide range of soils and is especially suited to well drained sandy soils of low fertility. It is very tolerant of high acidity. Varano is not suited to heavy cracking soil or to really waterlogged situations. Varano will grow on soils more alkaline or more salty, or with a higher clay content than will Townsville stylo.

#### CLIMATIC REQUIREMENT

Varano has been found more drought resistant than Townsville stylo. It is a heat loving plant growing at low lands in tropics. It grows in a rainfall from 500 to 1,270 mm per year with a pronounced dry season. It is susceptible to frost and above ground parts may die. It is suitable for elevations upto 1,800 meter.

#### ESTABLISHMENT

Varano can be established with seeds. Seed does not need inoculation and scarification. Simply broadcasting the seed on undisturbed land gives poor establishment. The land, therefore, should be lightly cultivated before broadcasting seed. On soil bunds, seed could be sown in lines. The seed-rate from three to six kg/ha is recommended.

#### FERTILIZATION

Generally no fertilization is applied.

#### WEEDING

Once the sward is established, it competes well with the weeds.

#### ASSOCIATION WITH GRASSES

It grows well with companion grasses and has been tested in grazing trials associated with sabigrass (*Urochloa mosambicensis*).

#### HERBAGE YIELD

Five to six tons per hectare in pure sward.

#### SEED PRODUCTION

Produces large amount of seeds giving about 700 kg/ha. There are about 271,600 with pods and 450,000 without pods of seeds in one kilogramme.

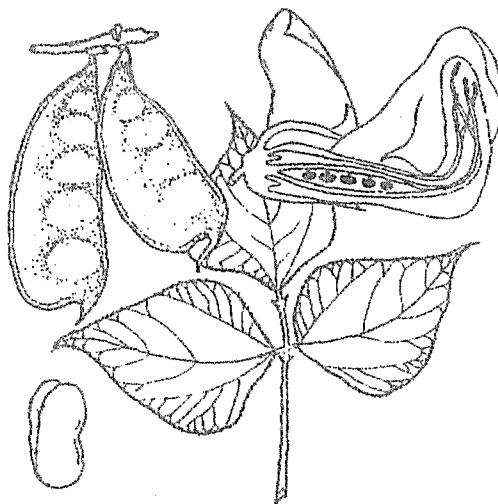
#### UTILIZATION

Very useful legume for dry season feeding. Even the seeds are eaten by livestock. It is suitable for planting on bunds and for improving depleted grazing lands at low altitudes.

### 3.2.2 LABLAB (Lablab purpureus)

#### PLANT DESCRIPTION

Lablab is widespread in tropics, especially in Africa. It is a climbing/erect annual or short-term perennial with long climbing stems. Its leaves trifoliate, leaflets large broad ovate, 3 to 15 cm. long and 1.5 to 14 cm. wide. Inflorescence is a lax fascicled of many flowered racemes of elongated peduncles. Flowers are white or blue or purple on short peduncles. The pods are four to five centimeters long, broadly scimiter shaped, smooth and beaked containing two to four seeds. Seeds are pale brown or buff ovoid, with a linear white conspicuous hilum.



#### SOIL REQUIREMENT

Lablab is extremely tolerant of soil texture, growing in deep sands to heavy clays with a good drainage. It will grow on wide range of pH from 5 to 7.5. But it is not quite resistant to salinity.

#### CLIMATIC REQUIREMENT

Lablab is a summer growing plant. It requires warm temperature with minimum temperature of about 3°C. It is tolerant to cold but its frost tolerance is low. It grows from sea level to upto 2,000 meter elevation under a wide range of rainfall. Once it is established, it shows good drought tolerance.

#### ESTABLISHMENT

Lablab is established easily with seeds. It needs well prepared seed bed but can even be broadcast on roughly cultivated lands. It is drilled in rows about one meter apart at a depth of about 2.5 to 5 cm. Planting can be done by machine or by hand dibbling. The seed rate of about five to seven kg/ha for drilling and eight to ten kg/ha for broadcasting is recommended. The seed should be covered or mixed with the soil for its germination. Lablab can also be established under maize when maize is about 100 cm. tall. Seed is dibbled in between two maize rows under adequate soil moisture. No seed treatment before sowing is necessary. Seed is generally inoculated before sowing.

#### FERTILIZATION

On fertile soils no fertilization is done but on poor sandy soils annual application of 50 kg. molybdenised superphosphate should be done.

#### WEEDING

Once established, lablab competes well with weeds but early growth is slow and weed competition should be avoided.

#### ASSOCIATION WITH GRASSES

Lablab is usually grown alone or in widely spaced crop of sorghum or maize.

#### HERBAGE YIELD

Lablab is a fast growing plant and is ready for harvesting or grazing after seven to ten weeks. In pure sward, about 5,000 to 8,000 kg/ha of dry matter can be expected. However, under irrigation very high yields are obtained. Lablab does not stand heavy grazing of stems but if only the leaf is eaten, it will provide two to three grazings in a season. Cutting or grazing should not be below 25 cm. from the surface.

#### SEED PRODUCTION

Lablab produces large amount of seed but over a long period. Therefore, matured pods should be hand harvested and dried. Seed can also be harvested by machinery. Seed yields of about 1,500 to 2,000 kg/ha have been reported. There are 3,300 to 4,300 seeds per kilogramme.

#### DISEASES AND PEST

The plant is attacked by Sclerotinia sclerotinium which causes stem rot. Lablab is also attacked by nematodes and leaf eating insects.

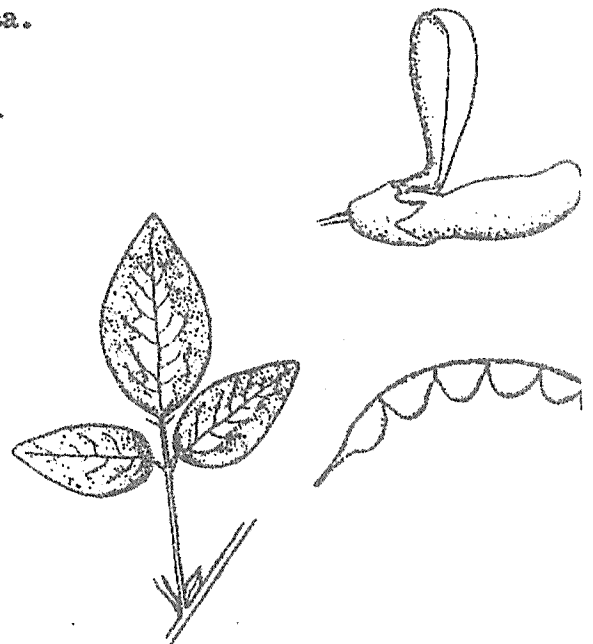
#### UTILIZATION

The fast growth of lablab can be utilized for quick soil cover to reduce soil erosion. It provides excellent high proteingreen feed for a short period. It can be conserved as hay and also as silage when grown mixed with maize or sorghum. Hungry cattle should not be allowed to feed on lablab as it can cause abloat problems.

### 3.2.3 SILVERLEAF DESMODIUM (Desmodium uncinatum)

#### PLANT DESCRIPTION

Silverleaf desmodium is a trailing perennial legume which is a native of Central and South America. Its stems are densely covered with short brownish hairs, leaves trifoliate with ovate leaflets, slightly hairy and dark green with well defined silvery spot or a strip along the midrib on the upper surface. Flowers are pale lilac pink in racemes, pods falcate, articulated, breaking into four to eight one-seeded segments, densely covered with minute hooked hairs and adhering to clothing. Seed is glossy, lens shaped, light brown or olive green in colour.



#### SOIL REQUIREMENT

Silverleaf desmodium is adapted to wide range of soils from well drained sandy to clay loams including moderately acidic soils with pH values of 5 to 5.5 but cannot tolerate salinity. It grows well on soils with light texture and not so well on compact heavy clays. It can withstand seasonal short term water-logging.



#### CLIMATIC REQUIREMENT

Silverleaf desmodium grows better in the warm climate of low lands, upto 2,000 meter altitude. More suitable temperatures are around 30°C. It has fair cold tolerance but it is susceptible to frost which may kill the top growth, but it recovers fast. It grows better in rianfall in excess of 900 mm.

#### ESTABLISHMENT

Silverleaf desmodium grows best when established in a well prepared seed bed but can be established on roughly cultivated lands and soil bunds. Generally, it is established with seed, but vegetative propagation is also possible. Seed is generally sown at the rate of five to seven kg/ha at a depth of about one centimeter in fifty to hundred centimeters rows. Seed can be sown by broadcasting but it should be rolled or harrowed. Generally, it is sown mixed with grasses.

There is a fare proportion of hard seed but machine harvested seed does not need scarification. Hand-harvested seed, however, should be soaked in water overnight before sowing. Desmodium needs special rhizobium and seed should be inoculated with this rhizobium before sowing. In certain cases, pelleting of seed with either rock phosphate or lime is recommended.

#### FERTILIZATION

Application of phosphate should be done at sowing, and annually about 50 kg.  $P_2O_5$ /ha should be applied. Need of other nutrients will depend on their availability in soils.

#### WEEDING

Generally, no weeding is done when sown mixed with grasses. However, in pure swards, one or two weedings may be useful in the early stages if weed competition is serious.

#### ASSOCIATION WITH GRASSES

Silverleaf desmodium when grown for forage is generally grown mixed with grasses. It has shown good growth with rhodes (Chloris gayana), setaria, (Setaria anceps) guinea (Panicum maximum) pangola (Digitaria decumbens) paspalum species and even with kikuyu grass (Pennisetum clandestinum). When left ungrazed, it tends to be aggressive and can suppress grass growth to some extent.

#### HERBAGE YIELD

Silverleaf desmodium does not withstand heavy grazing and optimum grazing management is the key for its long productive life. Dry matter yields in pure swards range from two to ten tons/ha. In a mixed sward about eight to ten tons/ha total dry matter is harvested. Yields, however, are lower under grazing. Yield of nitrogen fixed is about 90 to 160 kg/ha.

#### SEED PRODUCTION

Silverleaf desmodium is a prolific seeder. Seed can be either harvested by hand or machinery. Seed harvesting is little tedious because of stickiness of the pods. When hand harvested seed is stripped off the recemes and pressed into balls.

The pods are dried and seed is separated by rubbing. Seed crop should be harvested when more than 50% crop has shown maturity of pods. Pods turn brown or grey from green when matured. Seed yields of about 200 - 300 kg/ha are harvested from a well managed stand. There are about 200,000 to 240,000 seeds per kilogramme.

#### DISEASE AND PESTS

In Australia, silverleaf desmodium is susceptible to little leaf virus diseases. In Southern United States, it is affected by anthracnose caused by colletotrichum dumatium. In East Africa, the flowers are often damaged by Meloid beetle.

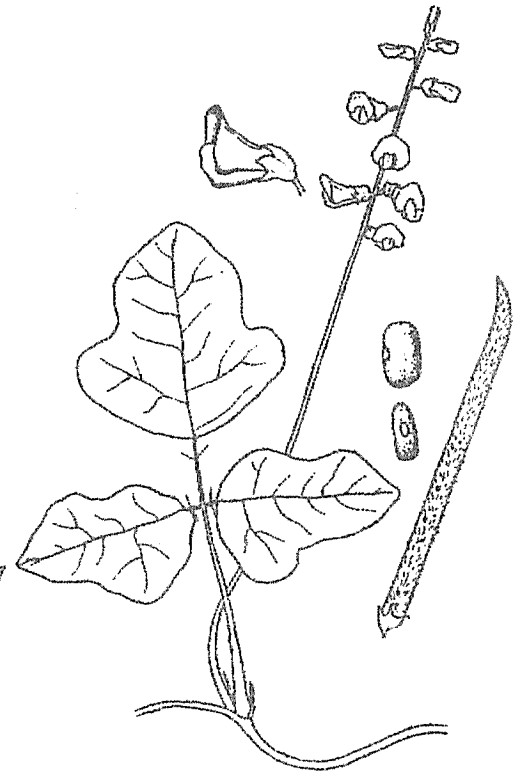
#### UTILIZATION

Silverleaf desmodium grows very well in Ethiopia at medium altitude and it could be a useful plant in soil and water conservation. On grazing lands, it is a very suitable source of protein when grown with grasses. Hay can be made but leaves fall off when overdried.

### 3.2.4 SIRATRO (Macroptilium atropurpureum)

#### PLANT DESCRIPTION

Siratro is a native of Central and South America. The commercially available siratro is a creeping perennial plant bred in Australia. It is a deep rooted plant and it also roots from the nodes. The leaves have three leaflets, are dark green and slightly hairy, oval, three to eight centimeter long and two to five centimeter wide. Lateral leaflets are often with a lobe on the outer side. Flowers are dark red, three to twelve crowded on axillary peduncles ten to thirty centimeter long. Pods are linear, straight but slightly curved at the apex, about eight centimeters long and five millimeter wide, with about twelve seeds. Seeds are light brown to black, ovoid in shape and flattened, 4 mm long 2.5 mm wide and 2 mm thick.



#### SOIL REQUIREMENT

Siratro grows on variety of soils and does not require particularly good soil. It grows well on volcanic ash and in general prefers light textured and well drained soils, although it can perform reasonably well on infertile and somewhat water logged ground but not on saline and acidic soils. It grows on quite shallow soils and is a good legume for hillside planting.

#### CLIMATIC REQUIREMENT

Siratro likes a moist, warm sub-tropical climate. It has good drought tolerance than many other legumes. It is burnt by frost but new shoots come out from subsurfaced crowns. Siratro yields much better in long day conditions. Suitable temperature range from 24/9°C to 33/28°C. Rainfall requirements are not high and siratro can be grown under moderately dry climate with annual rainfall of 700 to 800 mm. Best performance results under 800 to 1,600 mm in humid tropics. Grows upto 1,800 meter elevation.

#### ESTABLISHMENT

A clean seed bed is required for successful establishment. Except for seed production, siratro is generally planted in mixed swards with grasses. About two to four kg/ha seed rate is suggested when sown with grass. For seed production, it should be established in rows, about one meter apart and should be supported on trellises. Siratro with grass seed can be sown in rows about 50 to 80 cm. spacing, at a depth of about 2 cm. Siratro can also be oversown in native pastures or grasslands and about eight to ten kg/ha seed rate should be used for this purpose. However, best results are obtained when it is planted in cultivated strips. Broadcasting gives poor results but it can be done on burnt grasslands in the wet season.

There is a large percentage of hard seed and this can be reduced by soaking the seed in water for 24 hours before planting. Seed inoculation with cowpea type rhizobium is advised before sowing. However, this type of rhizobium is generally present in the soil.

#### FERTILIZATION

Siratro grows satisfactorily on relatively poor fertility soils but responds to adequate mineral nutrition especially phosphorus, potassium, sulphur, molybdenum etc. Annual application of about 40 kg  $P_2O_5$  and 60 kg.  $K_2O$ /ha are suggested. Calcium and molybdenum may be required for efficient nodulation.

#### WEEDING

Except seed crops, when sown with grasses no weeding are carried out. However, wherever necessary, one or two weeding to reduce weed competition may be useful.

#### ASSOCIATION WITH GRASSES

A number of grasses have shown good combination with siratro and they include pangola (Digitaria decumbens) guinea (Panicum maximum) plicatum (Paspalum plicatum) buffel (Cenchrus ciliaris) signal grass (Brachiaria decumbens) rhodes (Chloris gayana) etc.

#### HERBAGE YIELD

Siratro increases yield of herbage and its quality in the grass legume swards which is slightly less than nitrogen applied to pure grass. This positively influences the animal production.

Low and frequent grazing or cutting is detrimental to siratro growth and yield. For example, in one trial, yield of dry matter almost doubled when cutting intervals were increased from four to sixteen weeks and from three to nine weeks.

Therefore, heavy continuous grazing or cutting should be avoided. Depending on growing conditions, dry matter yields of about 6,000 to 8,000 kg/ha can be easily harvested.

#### SEED PRODUCTION

Siratro produces good quality seeds. However, to get maximum quantity of seeds, the plants should be supported on a fence or trellises. Siratro flowers over a long period and therefore should be hand harvested at frequent intervals. The matured but not dried pods should be picked quickly, else they split on the plant and seed shatters on the ground. Seed yields of about 200 to 300 kg/ha are common, but upto 1,000 kg/ha yields have been recorded under better managed stands. There are about 75,000 seeds per kilogramme.

#### PEST AND DISEASES

Siratro is affected by Pseudomonas phaseolicola, causing halo blight. In high rainfall area it may be affected by Rhizoctonia solani.

#### UTILIZATION

Siratro is a very good cover and forage plant for comparatively poor soils under low rainfall conditions. It can also be conserved as hay if properly dried. It serves as a good soil binding plant on eroded lands at low altitude.

### 3.2.5 STYLO (Stylosanthes guianensis)

#### PLANT DESCRIPTION

Stylo is a deep rooted perennial legume, much branched, erect or sub-erect and grows upto one meter tall. It is a native of Central and South America. Its stems are hairy which become woody at the base with age. The leaves are pinnately trifoliate with elliptic leaflets, 15 to 55 mm. long and 7 to 13 mm. wide. Inflorescence consists of several spikes of a few flowers crowded into terminal heads. Flowers are yellow or orange yellow and pods are hairy with one fertile joint and a very small beak. Seeds are yellowish brown and are tightly enclosed in a brown hulle.



#### SOIL REQUIREMENT

Stylo grows well on coarse textured, well drained soils but not so well on heavy clays. It tolerates poor soils of low phosphorus content and also tolerates acidic soils but it is not tolerant of salinity.

#### CLIMATIC REQUIREMENT

Stylo can grow under a wide range of temperatures and is more tolerant to cool weather conditions than other tropical legumes. It is adapted to frost free conditions and grows



actively at 15°C temperature. It grows best upto about 1,800 meter altitude. Stylo is adapted to 900 to 4,000 mm rainfall and it can survive long dry periods. It will also tolerate temporary flooding.

#### ESTABLISHMENT

Stylo can be established either with seed or with stem cuttings but the latter is less satisfactory. A fine seed bed is required for satisfactory establishment. Stylo should be sown at a depth of about 1.5 cm. with seed rates of one to three kg/ha in rows, 50 to 60 cm. apart. Seed should be scarified by rolling with gravel in concrete mixture drums or by keeping in water overnight. Seed should be inoculated but the rhizobium is generally present in most soils.

Stylo can also be established by oversowing in grasslands. Seed is broadcast after burning the old growth or after heavy grazing. Better establishment is obtained if the seed is broadcast after disturbing the soil for proper placement of seeds.

#### FERTILIZATION

Stylo grows well on marginal soils but application of phosphorus is essential on poor soils. About 50 to 100 kg/ha superphosphate is applied annually. Stylo also responds to application of potash and copper.

#### WEEDING

Stylo growth is very slow in the beginning and it is likely to get affected by weeds and therefore one or two weedings may be advisable.

#### ASSOCIATION WITH GRASSES

Stylo grows successfully with a number of grasses such as pangola (Digitaria decumbens), rhodes (Chloris gayana), buffel (Cenchrus ciliaris) setaria (Setaria anceps), guinea (Panicum maximum), spear (Heteropogon contortus) etc.

#### HERBAGE YIELD

Heavy grazing is detrimental to stylo in the first year. It should be lightly grazed or cut after six to eight weeks. When hand harvested, stylo should not be cut too low, else plants will die in the dry periods. Dry matter yield of about 8,000 to 10,000 kg/ha/year can be obtained based on four annual cuts.

#### SEED PRODUCTION

Stylo produces good seeds. The seed crop is harvested when most of the crop shows maturity. Harvested crop is dried and threshed to separate the seeds. If harvesting is delayed in the field, seed shedding takes place. The harvested crop can be cured for few days to allow post harvest maturity of seeds. Average seed yields of 100 to 200 kg/ha has been obtained. Higher yield can be expected when crops are managed under irrigation and fertilization. There are about 264,000 to 352,000 seeds per kilogramme.

#### DISEASE AND PESTS

Anthracoze has been reported to be affecting various cultivars of stylo. Corticium and Rhizoctonia solani attack it under wet conditions. It is attacked by the caterpillar of the moth lamprosema diemenalis and nematode Meloidogyne hapla on the root.

#### UTILIZATION

Stylo is a good forage crop for poor soils. Its deep root system and vigorous growth helps in good soil cover. It can be fed green or conserved as hay or left as standing hay in the field. Being a legume, it improves soil fertility.

### 3.3 TREE FODDER

#### 3.3.1 ALBIDA (Acacia albida)

##### PLANT DESCRIPTION

It is also called Faid-  
hervia albida. One of the largest  
of Acacia trees, native to Africa;  
is a valuable plant in arid and  
semi-arid regions. It grows upto  
30 m. high with upto 1 m. diameter  
of the trunk of breast height.  
Old trees have ascending branches  
and an umbrella shaped crown but  
young trees have a pyramidal shape.  
The tap root is extremely strong  
and tap roots upto 7 m. long have  
been measured on seedlings 5-6 cm.  
high, aged 9 months in Sudan. The bark  
is light grey, first smooth, then cracked. Trunk and shoots are  
almost white in young trees. The leaves are composite, blue  
green about 10 cm. long. Pinnulae are arranged in groups of  
3-10 with 6-23 pairs of foliolules. Strong white spines 1.5 cm.  
long are in pairs at the base of the leaves. Flowers are sessile  
in dense axillary bunches, 7 - 10 cm. long, creamy white, later  
pale yellow. Fruit is a thick indehiscent pod of a yellow orange  
colour, 10 - 15 cm. long, more or less curled and spiralled.  
The seed is shiny, ovoid, dark brown. There are about 10 - 20  
seeds per pod. Wood is light yellow in colour, fairly soft and  
lasting.



#### SOIL REQUIREMENT

It grows on a variety of soils but prefers deep sandy soils. It does not spread freely and naturally in clay soils which become dry and cracked in dry season, nor where soil permeability is poor nor where there is some factor preventing root penetration. It may be planted on heavy soils, provided that some deep preliminary waterings are given and there is a deep non standing water table. In arid zones, it is concentrated along drainage lines and in depressions.

#### CLIMATIC REQUIREMENTS

As long as water is available at a depth of less than 15 m. there is no difficulty in establishing this plant in areas receiving 450 - 800 mm. of rain. However, it can also be established with an assured rainfall of 300 - 450 mm. It is sensitive to cold and should not be planted under shade at higher altitudes. However, it has been found growing from sea level to upto 2,500 m. It is also sensitive to fire.

#### ESTABLISHMENT

Albida can be established with seeds or with nursery grown seedlings. The second method, however, is more successful. Fresh seeds germinate more uniformly than old seeds stored for a long time. Seed needs scarification which can be achieved by soaking the seed in boiled hot water and allowed to cool. Seeds can also be scarified by feeding to livestock and sheep are most effective for this purpose. To grow seedlings, two or three seeds should be planted in a polythene bag filled with well prepared soil. Ten to fourteen weeks are required to get well developed seedlings. The bags should be moved frequently and roots should be pruned. The height of seedling at planting

in the field should be about 25 cm. and if necessary, the seedlings should be clipped in the nursery to control its height. Planting in the field should be done at the beginning of the rainy season. Upto 400 trees can be planted per hectare which should be thinned down to about 100 giving a spacing of 10 x 10m. This can be further reduced especially on cultivated lands. Pitting requirement is same as for other forest planting.

#### MANAGEMENT

Development of seedlings from directly sown seed is slow. Seedlings are sensitive to competition from other species and they must be occasionally removed. Grazing should be avoided till the plants are well established.

#### YIELDS

Albida becomes really productive 10 to 15 years after planting. However, the tree survives for upto 80 to 100 years. Albida produces wood, high protein leaves and pods. From a well developed plant, about 10 to 20 kg. of dry leaves can be collected. The estimated yield of pods ranges from 100 to 600 kg/tree/year. However, this varies according to frequency of lopping the branches. Leaves and pods provide high protein feed to livestock. Percentage of crude protein in leaves and pods is reported to be about 15 to 20 and 10 to 15 respectively.

#### SEED PRODUCTION

Albida produces good quality seeds. The pods are collected when they fall on the ground after maturity. They are threshed and seed is separated. There are about 11,500 seeds per kilogramme weight.

#### UTILIZATION

Acacia albida plays a central role in several traditional agro-pastoral African systems. It is useful for its wood, foliage and fruits or pods. Wood is somewhat soft and it is used for making handicraft items, kitchen tools and saddles etc. but rarely used for carpentry. It produces an intensified biological activity in the soil and increases the fertility of land. The yield of crops from the lands where albida is grown have been more than doubled without any fertilization. The leaves and pods provide high protein feed for livestock, as a supplement with poor roughage. It is a good plant for soil cover on degraded hillsides, although the growth may not be ideal.

### 3.3.2 ALBIZIA (Albizia Lebbeck)

#### PLANT DESCRIPTION

Albizia is a quick growing deciduous tree, native to tropical Asia, Africa and North Australia. When planted as a shade tree, it can reach upto 30 m. high and a diameter of two to three meters. Its feathery foliage spreads like an umbrella. Its leaves contain six to twelve pinnules and 20 to 40 follioles and it produces white flower heads. Its long straw coloured pods rustle in the breeze. The seeds are flat and round. It is completely leafless for part of the year in certain growing conditions.

#### SOIL REQUIREMENT

Albizia does not have exact soil requirement though it prefers moist conditions and well drained soils. It can grow well in laterite, sandy ground near the sea and in other problem soils on the hilly areas. It has been observed growing well on poor steep mountainous soils with high acidity.

#### CLIMATIC REQUIREMENT

Albizia is found at altitudes upto about 1,500 m. in both dry and moist forests with annual rainfall as divergent as 600 to 2,000 mm. It sustains extreme climatic conditions with mean temperature ranging from 5°C to 40°C. It is resistant to droughts.



#### ESTABLISHMENT

Albizia can be planted with seed or seedlings or with cuttings. It coppices rapidly. When planted with seeds, the seeds should be treated or scarified with boiling water and left in the water for 24 hours. Generally, seedlings are grown in nursery for 10 to 12 weeks before rains and the well developed seedlings are transplanted in the field in well dug pits when good rains have been received. Even direct seeding has been satisfactory. Plant spacing varies according to use but can be planted at spacings of 5 x 5 to 8 x 8 m.

#### MANAGEMENT

Necessary management and care of seedlings should be done in the nursery till their planting in the field. In the field, the area around the seedlings should be kept weed free during early growth period. The area where albizia is planted should not be grazed, as cattle can destroy the albizia plants.

#### YIELD

Seeds are produced in great quantities. There are about 10,000 seeds per kilogramme. Pods should be harvested as soon as they ripe, dried and then seed separated. Foliage is lopped for animal feed or for green manure but yield estimates are not known. In India it is managed in rotations of 10 to 15 years or more, it produces about 5m<sup>3</sup> per hectare of wood.

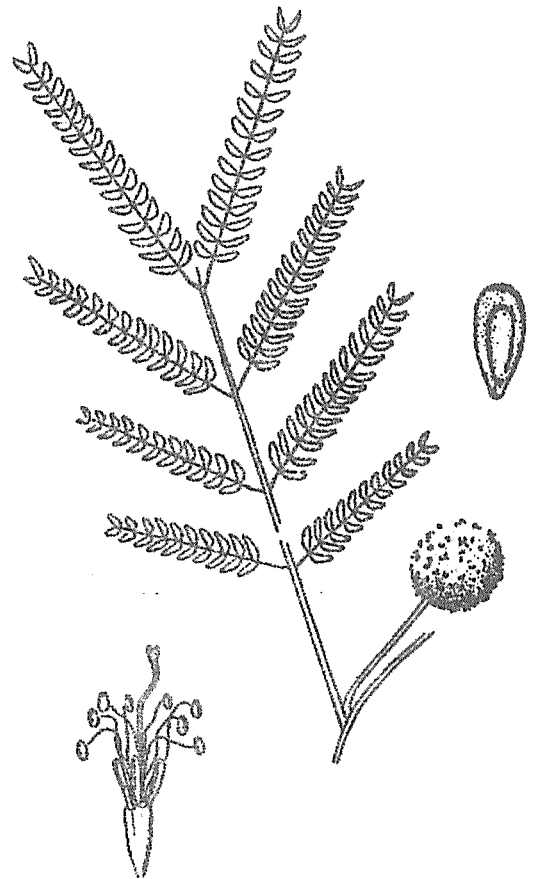
#### UTILIZATION

A good plant for shade, for planting along roads, around homesteads and for agroforestry. Produces good wood for fuel and timber. Leaves are fed to livestock. It adds nitrogen to the soil or makes good green manure crop. Albizia leaves have high nutritive value.

3.3.4 LEUCAENA (Leucaena leucocephala)

PLANT DESCRIPTION

Leucaena is a deep rooted shrub or tree of Mexico origin. It grows upto a height of 20 meters. The trunk and stems are woody, leaves are bipinnate, in four to nine pairs of rachis 15 to 20 cm. long. Leaflets, 11 to 17 pairs oblong, lanceolate two to three mm. wide, seven to ten mm. long. Inflorescence, capitate or globose, solitary axillary with peduncle, upto five cm. long and densely many flowered. Flowers are white, pods linear, flat upto 20 cm. long and 2 cm. wide, acuminate. Seeds elliptic, flat, shiny brown compressed, six to eight mm. long and three to four mm. wide.



SOIL REQUIREMENT

Leucaena requires well drained soils for good growth and high yield. It flourishes well in deep red soils. In Ethiopia, it has been found growing on variety of soils but with varying amount of growth. Leucaena does not stand flooding and waterlogging. Leucaena can stand soil acidity upto pH5 but grows much better in neutral or slightly alkaline soils.

It is also moderately tolerant of salinity. It also appears to be tolerant to low phosphorus status of soils.

#### CLIMATIC REQUIREMENT

Leucaena is a warm climate tropical plant. It grows best in temperatures between 22°C to 30°C and latitude 30N to 30S. Altitudes vary but growth slows down at higher altitudes. It has been reported growing upto 1,800 m altitude but grows best upto 1,000 m altitude. Leucaena requires 500 mm or higher annual rainfall, but because of its deep root system, shows remarkable drought tolerance. It may shed leaves in extreme dry conditions.

#### ESTABLISHMENT

Leucaena can be established either with stumps, seedlings or seeds. Pieces of trunks upto 10 cm. diameter and half a meter long can be rooted in nursery and then transplanted in the field. Best establishment, however, is obtained when about three months old seedlings grown in the nursery are transplanted in the field. Leucaena can also be satisfactorily established directly with seed in a well prepared seed bed. Thorough cultivation of land is necessary to kill weeds and obtain fine seed bed. When planted for fodder, leucaena seed should be planted in continuous rows about 100 to 150 cm. apart using seed rate of about five to ten kg/ha. The seed should be planted 2.5 to 5 cm deep in the soil. There is usually high percentage of hard seed and it should be scarified before sowing. A simple method is to keep the seed for about two minutes in water boiled upto 80°C, then wash with cold water and dry. Leucaena also needs special rhizobium for effective nitrogen fixation and the scarified seed should be inoculated before sowing.

#### FERTILIZATION

On acidic poor soil, application on lime and phosphorus at the rate of two to four tons and 50 kg/ha respectively is advisable. Even application of nitrogen in the early stage of establishment has been reported to be helpful.

#### WEEDING

Leucaena growth is very slow in the beginning and needs repeated weedings to reduce the weed competition. Alternatively, herbicides can be used but they are costly.

#### ASSOCIATION WITH GRASSES

Combines well with number of grasses. Generally, grasses are planted in between leucaena rows and the pasture is grazed or harvested.

#### HERBAGE YIELD

Yield of dry matter varies from place to place and from one cultivar to another. In dry conditions yield ranges between two to five tons/ha whereas in wet tropics, yields may be as high as upto 20 tons/ha/year. Leucaena should be harvested at the height of about 50 cm. at 10 to 12 weeks interval before flowering. When grazed, optimum stocking rate should be used, else it could be overgrazed. Alternatively, rotational grazing should be followed. If used for timber or fuel wood, the plants should be allowed to grow for two to three years or more and an average annual increment of 30 to 40 m<sup>3</sup> per hectare can be expected.

#### SEED PRODUCTION

Leucaena flowers profusely and produces large amount of seeds. Generally, seed is hand harvested. Pods shatter if they are allowed to dry on the plant and to avoid seed loss, the matured pods should be harvested when they change colour from green to dark brown before drying. No yield estimates are available. However, under repeated annual harvesting, a well managed crop yields seeds upto 1,000 to 1,500 kg/ha. There are about 20,000 to 24,000 seeds per kilogramme.

#### DISEASE AND PESTS

No serious diseases and pests have been reported.

#### UTILIZATION

Leucaena is used for variety of purposes. It is an excellent source of high protein concentrate feed supplement for ruminants. For efficient utilization and safety, leucaena should not be fed more than 50% of the total daily diet as green feed. Leucaena leaves can be dried and used as a source of concentrate. It is also used as an organic manure to cereal crops. It produces hard wood which makes excellent fuel wood for charcoal. In its early stage of growth, the plants are eaten by wild animals and needs protection.

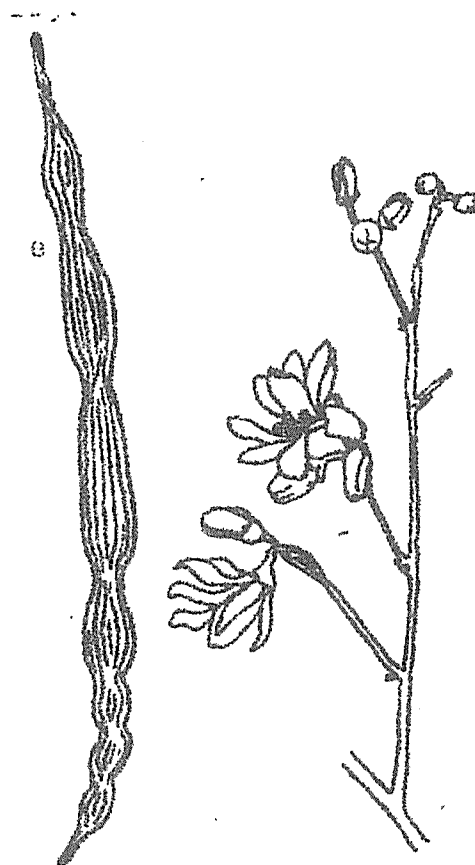
It can be planted in gully beds. It spreads profusely through root suckers. It is suitable for planting on soil bunds but needs care so that it does not invade the cultivated land as a weed.

Moringa (Moringa stenopetala)

Plant description

The origin of Moringa is reported to be in the subhimalayan arid zone and Arabia, but today it is widely distributed in the inhabited dry tropics of Africa. Amongst the five different species of Moringa reported in Ethiopia Moringa Stenopetala (cabbage tree or shiferaw) is the most common especially in Gamo Goffa region.

Moringa is a fast growing bush or tree reaching upto about eight to ten meters in height with more or less straight trunk. Its wood is soft and brittle and the bark is smooth greyish-green. The leaves are 3 pinnate with acute lanceolate leaflets to 5cm long and 2.5cm wide; pubescent apple green petiols to 2.5 cm long. The inflorescence a panicle of irregular white flowers which are strongly scented about 0.5 cm long slender pod upto 50 cm long and three angled with acute ends and an irregular embossed surface, first grey, then yellow and later brownish. The seeds are light and have three wings.



Soil requirement

Moringa grows on variety of soils particularly on deep coarse sands. It also prefers soils with high organic matter as it grows well

on rubbish dumps and wast plots and the fact that it is planted around houses where it gets benefits of house waste.

In Gamo Goffa, however, it has been seen growing on very marginal soils but growth is fast on heavier and fertile soils.

#### Climatic requirements

Moringa is a rather adaptable species which may be found in areas where rainfall is low and not regular every year (but where an underground water table is likely to be around) as well as in areas of having over 1100mm rainfall. However, its optimum seems to be between 300-400 isohyets. Once well established, it can sustain prolonged dry periods such as in the region of Gamo Goffa. It grows upto about 1800 m elevation but does not stand frost.

#### Establishment

Moringa can be easily established either with cuttings or with seeds. Both give satisfactory establishment under favourable growing conditions. The seeds germinate easily without any treatment. For growing seedlings in the nursery, seeds are sown in the polythene bags about two three months prior to field planting. At least two seeds are planted in the beginning but later on thinning is done to leave one seedling per bag. If the growth is fast, it should be topped off which would also help in hardening the seedlings. For planting with cutting, well grown, matured stems are cut and planted fresh in the pits dug earlier for planting in the field; their survival, however, will very much depend on the prevailing weather conditions at planting.

#### Management

Moringa does not need any special management, except to avoid weed competition in the early stage and to keep safe from livestock till the plants are high enough.



### Seed production

Produces a large amount of seeds during the season. The matured pods are harvested, dried and seeds are separated. The seeds should be dried well before storage.

### Utilization

There are many and varied uses of moringa which make of this species one of the most valuable in the arid zones as is observed in Gamu Goffa region where farmers grow it on cultivated fields forming an effective agroforestry system. It is commonly used for the following:-

- a) Cuttings planted in lines close to each other constitute a live fence around the houses and gardens.
- b) Its green leaves and pods are used as green vegetables. These are palatable and nutritious both for human beings and live-stock. In dry areas, this is an important source of green matter when other green vegetables are not available.
- c) Roots and bark of moringa are used in various antiascorbic preparations. The bark is also used for aperitive and digestive properties and for tanning hides.
- d) Seeds contain oil which does not thicken or become rancid, hence its use in clock work and for the extraction of particularly delicate perfumes. The oil is also used for cooking. The oil cake is not suitable for animal feeding but it is an excellent fertilizer.
- e) Moringa seeds are reported to be having water clarifying qualities. In an experiment ground moringa seeds (200 mg/litre of water) were able to reduce the turbidity of river water with 8000 mg/litre of total solids by 98% after an hour. The number of bacteria in the water can also be reduced. This quality needs further testing for the benefits in rural areas for cleaning drinking water (these observations are based on the work done in Federal Republic of Germany).

### 3.3.4 OLDMAN : SALTBUSH (Atriplex nummularia)

#### PLANT DESCRIPTION

Oldman saltbush is a perennial halophyte or saltloving shrub, indigenous to Australia. However, now it is grown in many countries throughout the world. It can grow upto a height of three meter and can also form bushes with a diameter of three meters. It has a well developed tap root system together with a horizontal basal root development. Its leaves are bluish grey in colour, covered with a white layer and small salt cells. The leaves are more or less round but broader than their length. The male and female flowers are borne on separate plants and they are wind pollinated. The male flowers are small, round and yellowish. Female flowers have same colour as the leaves and are borne in clusters. The seed consists of two leathery or papery scale leaves which have grown together around the small round reddish brown seed.

#### SOIL REQUIREMENT

Oldman saltbush is adapted to wide variety of soil conditions, even grows on bare alkaline patches. It also grows on heavy textured clay soils with poor drainage. Acid and leached sandy soils usually contain too little sodium and potassium salts for good production from halophytes.

#### CLIMATIC REQUIREMENT

Oldman saltbush is a very drought resistant plant and grows in the rainfall range of 150 to 200 mm. Well established plants are reported to have withstood as low rainfall as 50 mm per year. The salt in roots and leaves maintain high osmotic value to cell sap, thus making it drought resistant. It is

also resistant to temperatures as low as 10°C-12°C. It grows in cooler areas but gets affected by frost and recovers quickly.

#### ESTABLISHMENT

Oldman saltbush can be established with seedlings or cuttings. The soil should be thoroughly prepared. The scale leaves on the seed contain high salt and it acts as germination inhibitor. The salt is, therefore, leached before planting by washing seed in running water or by soaking seed in water for two to three days. The water should be changed two to three times daily. Seed is sown immediately after treatment. It is advisable to grow seedlings in the nursery. Optimum temperatures for germination are 15°C to 20°C. Seedlings are transplanted when they attain height of 15 to 20 cm. in three to four months period. Depending on spacing, about 2,500 to 5,000 plants are required for one hectare.

When planted with cuttings, the young stems not thinner than 6 mm. and approximately 250 mm. long are cut between two leaf axile. About half of the cutting is buried in the moist soil and is pressed in the soil. Generally, these cuttings sprout in six weeks time and then they are transplanted in the field after about ten weeks period.

#### MANAGEMENT

The seedlings need good attention in the nursery. In the field, these seedlings attract rodents and wild animals which eat the seedlings. In very dry conditions and wherever possible the plants are watered during the early stage of growth. Grazing should be commenced when plants are about 1.5 m. high which is often second or third year. Plants be allowed to recover completely after grazing or cuttings.

#### YIELD

The oldman saltbush produces high yield of green succulent foliage under relatively poor moisture conditions. The annual yield of two to four tons/ha. dry matter has been reported from well grown stands. The quality of foliage is reported to be high, containing about 12 percent digestible protein.

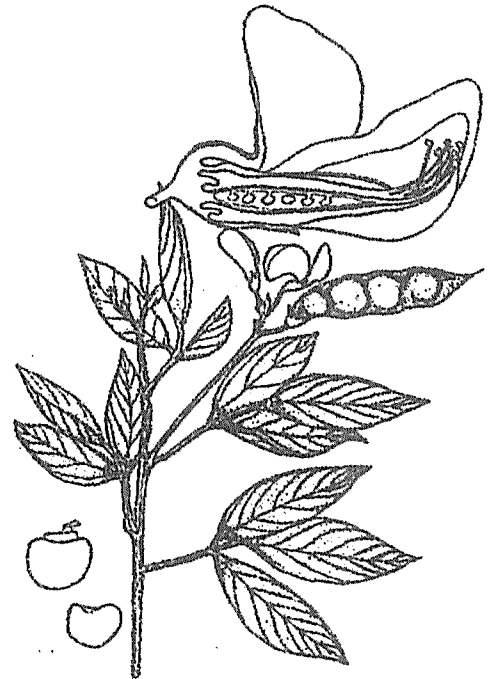
#### UTILIZATION

Oldman saltbush is suitable for stabilizing sandy soils. It produces high amount of green foliage in the semi-arid climatic conditions which provides feed for livestock. In Ethiopia, this plant is found growing as a hedge in Addis Ababa and some recreation areas. In semi-arid regions of Eritrea and Tigray, this plant could be useful for the rehabilitation of degraded rangelands.

### 3.3.5 PIGEON PEA (Cajanus cajan)

#### PLANT DESCRIPTION

Pigeon pea is a native of Egypt, East Africa and India. It is a woody, short-lived perennial shrub, one to three meters tall, with deep tap root and long laterals. Stems are angular, hairy and branched. Branching begins 15 to 20 cm. above ground. Leaves are trifoliate, spirally arranged. Inflorescence, a small terminal or axillary raceme 4 to 12 cm. long. Flowering extends over several weeks. Colour of the flowers is yellow brown or purple. The pod is flat with two to eight seeds.



#### SOIL REQUIREMENT

Pigeon pea grows on variety of soils. Its deep tap root and extensive laterals tolerate low soil fertility and low moisture. It thrives in light sandy soils but grows best in neutral deep loams that are not poor in lime, with a soil pH range of five to seven. It has shown good growth on poor hilly soils in Ethiopia.

#### CLIMATIC REQUIREMENT

Pigeon pea has wide adaptability and grows well in semi-arid regions with less than 200 mm. rainfall but it grows best when there is good rain during the first two months, followed by a dry period for flowering. Pigeon pea is not much suitable to humid tropics. It is frost sensitive and growth temperature ranges between 18°C to 30°C. It grows well upto 2,000 m. altitude and with rainfall between 600 to 1,000 mm.

#### ESTABLISHMENT

Pigeon pea is usually grown mixed with sorghum, maize or millets and also as pure crop. The land preparation should be done as for any other crop, a fine compact seed bed is desirable. Too old seed should not be used as it loses viability in storage. When sown in pure stand, a plant spacing of 30 to 50 cm. and row spacing of about one meter is followed. However, this will vary according to plant size. When planted mixed with other crops, one or two rows of pigeon peas are alternatively sown after every three to five rows of other crops. Thus, the seed rate for pure crop should be about ten to twenty kg/ha and in mixed swards about two to six kg/ha. The depth of planting should be about 2.5 to 4 cm. Seed is generally not inoculated before planting. It can also be established on soil bunds in cultivated lands and grasslands for multipurpose utilization in rows, about two meters apart.

#### FERTILIZATION

Generally, no fertilization is done but when planted for seed production, annual application of 50 kg/ha. super phosphate is suggested.

#### WEEDING

One or two weedings are necessary in the early stage of growth.

#### ASSOCIATION WITH GRASSES

Pigeon pea can be planted with many grasses but grazing has to be controlled. Generally, when it is grown for seed production it is planted mixed with crops such as maize, sorghum etc. or in pure swards.

#### HERBAGE YIELD

When grown for seed production, pigeon peas should not be harvested for fodder and it should be allowed to flower and seed. But when utilized for fodder, green branches are cut and fed to the cattle. Harvesting of forage should be done before or at flowering. If grazed, rotational grazing should be followed. However, there is a danger of plants being damaged by cattle. Heavy grazing should be always avoided. When hand harvested, it should be harvested at about 20 to 30 cm. height from the ground level. Dry matter yields upto 10 to 15 tons per hectare have been reported under good management systems.

#### seed production

It flowers unevenly and therefore matured pods should be harvested with hand. Pods do not shatter at maturity. Harvested pods should be dried before threshing. Seed yields of 1,000 to 1,500 kg/ha are obtained. There are about 6,000 seeds per kilogramme.

#### DISEASES AND PESTS

Pigeon pea is affected by wilt (Fusarium udum) and collectotrichum cajani leafspots. Stem canker caused by Physalasporea is also reported. It is also affected by caterpillars, pod borers and gal fly.

#### UTILIZATION

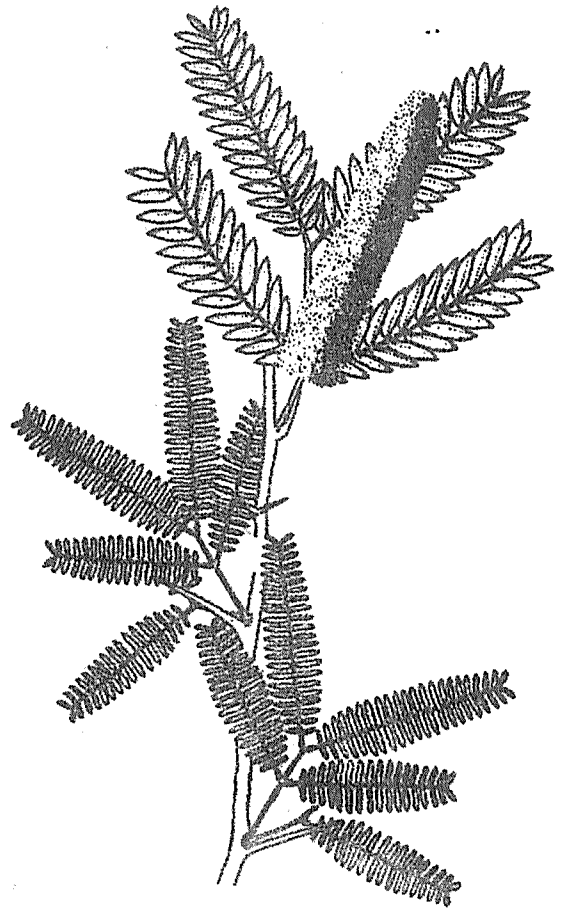
Pigeon pea is a useful plant for planting on contour bunds, terrace risers and on grazing lands. Its seed is a good source of protein for human and livestock. Straw and green leaves make high protein forage and the dried branches are used for making roof or for fuel. It can also be planted as a hedge around the house and farm.



### 3.3.6 PROSOPIS (Prosopis juliflora)

#### PLANT DESCRIPTION

Prosopis is a native to many Central and South American countries. It is a fast growing deciduous, deep rooted legume shrub or tree which in favourable environment can grow upto 10 to 20 m. tall and with a trunk diameter of one meter. Most species have spines but spineless species also occur. Leaves, dark green are compounded by numerous leaflets and have feathery appearance. Flowers are small, usually clustered in elongated spikes or spherical heads. Pods long, fleshy are produced in clusters on small stalks upto 12 to 20 cm. long either flat or coiled into spiral and contain several seeds embedded in sweet dry yellow pulp.



#### SOIL REQUIREMENT

Prosopis grows on variety of soils but does well on sandy soils. It can tolerate and even grow rapidly in barren wasteland. It thrives in light sandy or rocky soils in the desert. Some species are salt tolerant.

#### CLIMATIC REQUIREMENTS

Prosopis grows in a very warm dry climate and it is highly drought resistant. The plant roots penetrate to great depth in search of moisture. Rainfall requirement is between 150 to 600 mm. Altitude ranges upto 1,500 m. Some varieties do not show frost tolerance.

#### ESTABLISHMENT

Prosopis is generally planted directly with seed or with seedlings grown in nursery for 12 to 14 weeks. Seed has a hard coat and needs to be scarified by treating with boiling water and allowed to soak for 24 hours as the water cools. Generally, it is planted in polythene tubes in the nursery under controlled growing conditions and well developed seedlings are planted in the field during the wet season. Plant spacing vary according to plant size but could be spaced from 5 to 10 m. apart. It can also be established with stem stumps but production of pods and foliage is comparatively less than plants grown with seedlings.

#### MANAGEMENT

Young seedlings need good care in the nursery. When planted in the field, watering may be necessary in absence of adequate rains. Weeding is necessary during establishment period in the field. A micro catchment should be prepared around the plant on sandy soils in low rainfall areas.

#### YIELD

Prosopis is a good source of firewood, timber and food for human and animals. Palatability of leaves is fair but pods are most palatable and nutritious and are source of protein and carbohydrates. Cattle, sheep, horse, goats, donkey and wild life survive on these. Pods may also be ground for human consumption. Pods should be harvested before full maturity. On a 10 to 15 year rotation, the expected yield of wood range from 50 to 60 tons/ha.

#### DISEASES AND PESTS

Bruchid beetles often damage much of the prosopis seed crop.

#### UTILIZATION

For erosion control, stabilizing shifting desert or coastal sand dunes, for wind breaks, shelter belts and for reforesting dry wastelands. Good source of fuel wood, timber and charcoal, feed and fodder for livestock.

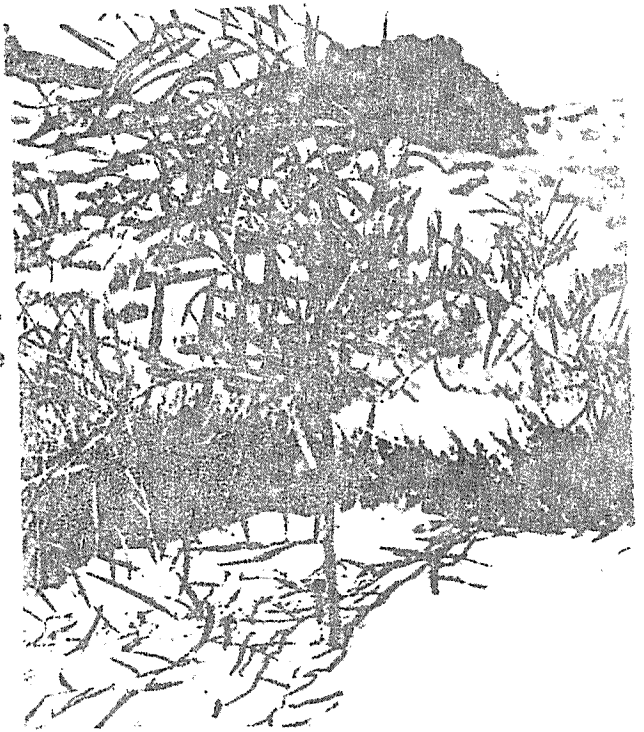
#### LIMITATION

It is an aggressive plant. Once established, it can become a weed and invade agricultural lands.

### 3.3.7 SALIGNA (Acacia saligna)

#### PLANT DESCRIPTION

Acacia saligna also a known as Acacia cynophylla is a native of Western Australia. It is a much branched small tree with a sprawling habit and weeping branches. The bark on the stem is smooth, greenish grey to brownish grey in colour. The root system is well developed, both laterally and in depth. The roots close to the surface are densely covered with nitrogen fixing nodules. The branches are flexible and highly divided. The leaves are pinnate when young and then replaced by phyllodes, widely or narrowly lanceolate, sometimes, slightly sickle shaped with a clearly marked mid rib. Flowers are in clusters of 3 to 8 inches glabulous heads of a bright yellow colour, on short axillary twigs. Fruits are flat pods, somewhat narrowed between seeds and slightly arcuate. Seeds are dark greenish brown. Wood is differentiated in yellowish white sapewood and reddish brown heart wood.



#### SOIL REQUIREMENT

It is a hardy plant and widely adapted to barren slopes, and lands with poor soils. It can be seen growing from coastal sandy plains to river banks and small rocky hills and slopes.

But the best results are obtained on deep sandy calcareous soils. The tree is sensitive to sea water spray but tolerates acidity and alkalinity to some extent.

#### CLIMATIC REQUIREMENT

Acacia saligna grows throughout the tropical and warm temperate regions of the world. It will grow under both dry and moist conditions but it is famous for its drought tolerance. The rainfall varies from 200 to 1,000 mm. Its best growth is between temperatures ranging from 13°C to 30°C and it does not stand frost.

#### ESTABLISHMENT

The usual method used for establishment of *Saligna* is by growing seedlings in a nursery and later transplanting in the field. It can also be established by direct sowing in the cultivated land. The seeds need scarification treatment and it can be easily achieved by dipping in boiling water. The seed is dipped in equal volume of boiling water removed from the source of heat and allowed to cool for 24 hours. Seedlings are raised in polythene bags. In humid conditions plantation of stumps may also be used. Bare rooted seedlings are cut back and their roots pruned before planting. Well grown 90 to 120 days old seedlings are planted in the field, when good rains have been received. The spacing of planting varies, but in regular rows, a spacing of about 1 m x 2 m should be followed. When inter-planted on grazing lands, low plant density is desirable.

#### MANAGEMENT

This species is usually managed as a coppice with a 5 - 10 years rotation. Grazing and cutting should be avoided till the plants are well established.

#### YIELD

When harvested for feed, branches with foliage should be harvested not less than 50 cm. above ground. It should be allowed to grow sufficiently before next harvest is taken. In Mediterranean regions, in areas with 600 - 700 mm rainfall, 6 - 12 m<sup>3</sup> of growth per hectare/year has been reported.

#### SEED PRODUCTION

Produces good quality of seed in large amounts. The seeds are hand harvested when the pods are matured. There are about 60,000 seeds per kilogramme.

#### UTILIZATION

In spite of its short life span, it has been found effective in reforestation of gullies and degraded hillsides because of its ability to coppice and producing suckers. The high feed values of leaves and pods make it valuable species for feeding farm animals. The leaves, however, have low palatability. The wood is suitable for fire wood, fencing and paper. Gum can also be collected from damaged bark.

### 3.3.8 SESBANIA (Sesbania grandiflora)

#### PLANT DESCRIPTION

Sesbania is a fast growing small tree which is native to many Asian countries. But now it is grown in most of the tropical countries. In most countries, Sesbania is commonly seen growing on dikes between rice paddies, along road sides and in back yard gradens. Sesbania grows upto about 10 m. high with a diameter of about 30 cm. It has rather stout branches which are pubescent when young. Its flowers are like butterfly and very large upto 10 cm. long with pink, red or creamy white colour. The fruit is a pod, long and cylindrical, containing about 50 seeds which are processed and eaten like soya-bean. The bole is straight and cylindrical and wood is white and soft. The bark is light grey deeply furrowed and corklike in feature.



#### SOIL REQUIREMENT

Sesbania grows on a very wide range of soils including black poorly structured clay. Its extraordinary nodulation helps restore fertility of these soils. Sesbania does not tolerate acidic soils.

#### CLIMATIC REQUIREMENTS

Sesbania grows best in warm and humid environment and it is sensitive to frost. It can grow upto about 1,500 m. from sea level. It grows best when annual rainfall exceeds 1,000 mm. with a short dry season.

#### ESTABLISHMENT

Sesbania can be established with either seeds or cuttings or seedlings. It establishes very rapidly and needs little maintenance. When planted with seed, the land should be thoroughly cultivated. It can be planted in rows, one to two meter apart on grazing lands or on soil bounds. Spacing between plants should be wider when grown for wood production. The seed does not need any treatment before planting. About 10 kg/ha seed rate is suggested. When planted with seedlings, they should be raised in nursery for about six to eight weeks before planting in the field. The fast growing seedlings should be topped off after about four to six weeks growth. This reduces shade on young seedlings, reduces lodging and hardens the seedlings.

#### MANAGEMENT

Sesbania is easy to manage. Because of its fast growth weed competition is minimum. It also fixes nitrogen which helps in improving soil fertility. When grown for forage or green manure, the young branches are harvested three to four months after planting. But when grown for wood, lopping of green foliage should be minimum. It grows fast after harvesting, provided moisture is not a limiting factor.



#### YIELD

Yield of foliage and wood varies according to growth which depends of soil and climate. Wood yields of 20 to 25 m<sup>3</sup> per hectare per year are common, three to four years after planting. When grown for forage, its plant density is high and it produces upto 50 tons of green material in six to eight months period.

#### DISEASE AND PESTS

Sesbania is very susceptible to nematodes. Damage by birds and grasshoppers is also reported.

#### UTILIZATION

Sesbania is useful for variety of purposes:

1. Its pods and leaves contain high amount of protein and it makes excellent food for human beings and for livestock;
2. Its wood is used for fuel and pulp and paper making;
3. It is excellent source for green manure;
4. It holds promise for reforestation and combines well in agroforestry systems;
5. The bark yields clear gum and tanning agent.

## SESBANIA (Sesbania aculeata)

### Plant Description

Sesbania aculeata or Sesbania bispinosa is a native of tropical and subtropical areas of Indian subcontinent but now it has spread to many countries in the tropics. It is a annual spreading leguminous shrub plant but grows straight into a small tree in crowded stands with slender stems that may reach 7m tall. It is a fast growing and vigorously nodulating plant and is particularly preferred for green manuring & soil improvement.

The plant has shallow root system and it is copiously branched with pinnate leaves. Leaf rachis, 5-10 cm long, usually more or less pilose & rarely glabrous. Leaflets 9-20 pairs, upto 2.5 cm long. Inflorescence, about as long as the leaves with yellow flowers. Pods, long acuminate at the apex, transversely divided, upto 15cm long glabrous, twisted.

### Soil Requirement

It is well adopted to difficult soil conditions. It will grow on saline and alkaline waste lands, wet and almost waterlogged soils. However, best growth is obtained on heavier soils. Although it has been growing on poorer soil in Ethiopia but its growth is rather slow.

### Climatic Requirement

It is an extremely versatile plant and grows well in tropics and subtropics. Even successful plantation trails have been reported in temperate regions eg. in Italy. It has been reported to grow from sea level upto 1200m but in Ethiopia satisfactory growth has been observed upto about 2000m elevation. Although it has shown good drought tolerance but best growth is obtained in high rainfall areas ranging from 550 to 1000mm or more in the tropics. Growth rate is slow in low temperature areas.

### Establishment

Sesbania can be easily established directly with seed and no presowing treatment of seed is necessary. It can be sown in rows at the seed rate of 5kg/ha on the grazing lands or on the soil bunds or between crops as alley cropping. If used for green manuring, it is generally sown broadcast at the seed rate of about 40-60 kg/ha. For successful establishment on degraded lands, nursery grown 2-3 months old seedlings can be planted with high rate of establishment.

### Management

Sesbania does not need any special management except in some cases one or two weedings may be required after planting. Livestock like sesbania very much & it should be saved from grazing till the plants are big enough. For green manuring, it should be harvested in 10-12 weeks period. If utilized for animal feeding grown up branches should be lopped to feed livestock, frequency of harvesting however, will depend on its speed of regrowth.

### Seed Production

Sesbania flowers within five to six months after planting and it is a prolific seeder. As the pods shatter, matured pods are harvested before they dry on the plant. From a well grown stand about 1500kg/ha seed could be harvested annually. There are about 88000 seeds in one kilogramme. In order to collect more seeds/plant the plant should be topped off to force branching & greater flower production.

### Utilization

- 1) It is a useful multipurpose plant species for revegetating degraded lands.
- 2) The fresh & young foliage is high in protein content & it is highly palatable feed for cattle & sheep.
- 3) The green leaves make excellent source of green manure to improve fertility of the poor soils. It could also be grown on cultivated fallow lands to improve the soil & reduce the fallow periods.

- 4) The stems make useful fuel wood
- 5) The stems also provide fibre which is for making fishing nets & gunny bags.
- 6) It is a potential source of pulp for paper products & construction material.
- 7) Seeds contain water soluble gum which fetches good price.
- 8) The plant is used for wind breaks, live fencing, erosion control, shade & cover crop & for suppressing noxious weeds.

## Summary of the Characteristics of Multipurpose Plant Species

Plant Species	Suitable Soils	Altitude (meters)	Rainfall (mm)	Seed-rate (kg/ha)	Seed Treatment	Tolerance to	
						Drought	Water-logging
(A) Grasses							
1. <u>Cenchrus ciliaris</u> (Buffel)	Light textured well drained soils	Upto 1800	350-1000	3 - 5	Six months rest period after harvest	Very good	Poor
2. <u>Chloris gayana</u> (Rhodes)	Light textured loam soils	Upto 2000	600-1000	4 - 6	No dormancy but seeds improve in storage	Good	Fair
3. <u>Panicum maximum</u> (Guinea)	Well drained medium textured fertile soils	Upto 1800	650-1800	4 - 10	Six months rest period after harvest	Good	Poor
4. <u>Phalaris aquatica</u> (Phalaris)	Heavy fertile soils	Above 2000	430-650	6 - 10	No treatment	Very good	Good
5. <u>Pennisetum clandestinum</u> (Kikuyu)	Heavy fertile soils	Above 1800	1000-1600	3 - 6	No treatment	Fair	Fair
6. <u>Pennisetum purpureum</u> (Napier)	Well drained heavy fertile soils	Upto 2000	800-1000	Cuttings <sup>2</sup>	No treatment	Fair	Poor
7. <u>Setaria anceps</u> (Setaria)	Well drained fertile soils	Upto 2000	500-700	5 - 10	No treatment	Fair	Good
8. <u>Sorghum albanum</u> (Columbus)	Black alluvial soils	Upto 1800	400-800	5 - 7	No treatment	Good	Fair
(B) Legumes							
9. <u>Desmodium uncinatum</u> (Silverleaf desmodium)	Well drained sandy loam soils	Upto 2000	800-1000	2 - 4	Seed inoculation	Fair	Fair
10. <u>Lablab purpureus</u> (Lablab)	Deep sandy to clay loam soils	Upto 2000	700-2000	5 - 7	-	Good	Fair
11. <u>Macroptilium atropurpureum</u> (Siratro)	Light textured low fertility soils	Upto 1700	700-800	4 - 4	Seed scarification	Good	Fair

Plant Species	Suitable Soils	Altitude (meters)	Rainfall (mm)	Seed-rate kg/ha	Seed Treatment	Drought	Tolerance to Water-logging
12. <u>Stylosanthes guianensis</u> (Stylo)	Coarse textured well drained soils	Upto 2000	900-4000	1 - 3	Seed scarification	Good	Fair
13. <u>Stylosanthes hamata</u> (Varano stylo)	Poor scrub soils	Upto 1800	300-1250	3 - 6	Seed scarification	Very good	Poor
(C) Tree Fodder							
14. <u>Acacia altida</u> (Altida)	Deep sandy loam soils	Upto 2000	450-800	Seedlings	Seed scarification	Good	Poor
15. <u>Acacia saligna</u> (Saligna)	Poor rocky soils	Upto 2000	450-800	Seedlings	Seed scarification	Good	Poor
16. <u>Albizia lebeck</u> (Albizia)	Well drained medium soils	Upto 1800	900-2000	Seedlings	No treatment	Good	Poor
17. <u>Atriplex nummularia</u> (Atriplex)	Poor sandy soils	Upto 1800	150-200	Seedlings or cuttings	No treatment	Very good	Fair
18. <u>Cajanus cajan</u> (Pigeon Peas)	Variety of soils	Upto 1800	600-1000	2 - 6	No treatment	Good	Fair
19. <u>Leucaena leucocephala</u> (leucaena)	Well drained heavy fertile soils	Upto 1800	500-2000	5 - 10 or seedlings	Seed scarification and inoculation	Good	Poor
20. <u>Moringa stenopetala</u> (Moringa)	Variety of soils	Upto 1800	500-1100	seedlings	No treatment	Good	Poor
21. <u>Prosopis juliflora</u> (Prosopis)	Sandy or Rocky desert soils	Upto 1800	150-600	Seedlings	Seed scarification	Very good	Poor
22. <u>Sesbania grandiflora</u> (Sesbania)	Heavy well drained soils	Upto 1800	1000-2000	Seedlings	-	Fair	Fair
23. <u>Sesbania aculeata</u> (Sesbania)	Poor scrub soils	Upto 2000	550-1000	Seed or Seedlings	No treatment	Good	Fair

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