COURSE CODE:	PRM 505
COURSE TITLE:	Principles of Pasture and Range Sciences
NUMBER OF UNITS:	3units
COURSE DURATION:	Two hours lecture and three hours practical per week

COURSE DETAILS:

Course Coordinator:	**Prof. Alaba Olufunmilayo Jolaosho**
Email:	**jolaoshoao@unaab.edu.ng**
Office Location:	**Room 2, PRM Department, COLANIM**
Other Lecturers:	**Dr T. A. Amole**

COURSE CONTENT:

Botany and systematics of pasture plants, identification and classification of tropical forage species, pasture improvement programmes and breeding, methods of propagation, physiology of pasture plants, tropical climate and implication on pasture production, vegetation belts of West Africa and adaptation of forage species, soil – plant – animal interrelationships, some pasture terminologies

COURSE REQUIREMENTS:

This is a compulsory course for students in the College of Animal Science and Livestock Production. In view of this, students are expected to participate in all the course activities and have minimum of 75% attendance to be able to write the final examination. There class tests at the end of every three weeks of lecture.

READING LIST:

1. Whiteman, P.C. 1980: Tropical Pasture Science. Published by Oxford University Press.
2. Hogson, J. and Illius, A. W. 1996: The Ecology and Management of Grazing Systems. CAB International Wallingford, USA.
3. Micheal, B. Jones and Alec Lazenby, 1988: The Grass Crop. The Physiological Basis of Production, Chapman and Hall LTD., USA.
4. Pearson, C. J. and ISN, R. L. 1987: Agronomy of Grassland Systems. Cambridge University Press NY.
5. Crowder, L. V. AND Chheda, H.R. 1982. Tropical Grassland Husbandry. Tropical Agriculture Series. Longman, London.
6. Humpherys, L. R. 1991: Tropical Pasture Utilization. Published by the Press Syndicate of the University of Cambridge NY.
7. Bogdan, A. V. 1977: Tropical Pasture and Fodder Plants (Grasses and Legumes). Tropical Agriculture Series. Longman London

LECTURE NOTES

BOTANY AND SYSTEMATICS OF GRASSES AND LEGUMES

Grasses belongs to family Gramineae (Poaceae). They are made up of two main parts: shoot or tillers (aerial parts) and roots (subterranean parts) with the reproductive parts included at flowering. They are MONOCOTYLEDONOUS i.e. possess one seed leaf. They are HERBACEOUS (non-woody), divergent in size, shape and growth habit, can be annual or perennial in life form.

A. VEGETATIVE ORGANS

1. AERIAL PARTS

The shoots consists of the stem (culm, haulm) and the leaves. The **stems** are cylindrical or rounded and jointed i.e made up of **nodes** separated by **internodes**. Internodes can be hollow (e.g. *Brachiaria mutica)* filled with white pith (e.g. *Zea mays, Sorghum vulgare and Hyparrhenia spp.*) or solid e.g. *Axonopus scoparius).* stems can be glabrous or pubescent. Shoots develop from buds found at the nodes and produce side branches.

The basal portion of tufted grasses is called CROWN. Stolons are creeping stems that grow above the surface of the ground and develop roots and shoots at the nodes. Examples of grasses with stolons are *Pennisetum clandestinum*, *Cynodon nlemfuensis* and *Digitaria pentzii*.

The leaves consists of the sheath, ligule and the leaf blade. leaf blades are borne on sheaths. Leaves are situated on stem in opposite rows alternatively. The leaf sheath have free edges and chlorophyll. Leaves could be smooth or rough

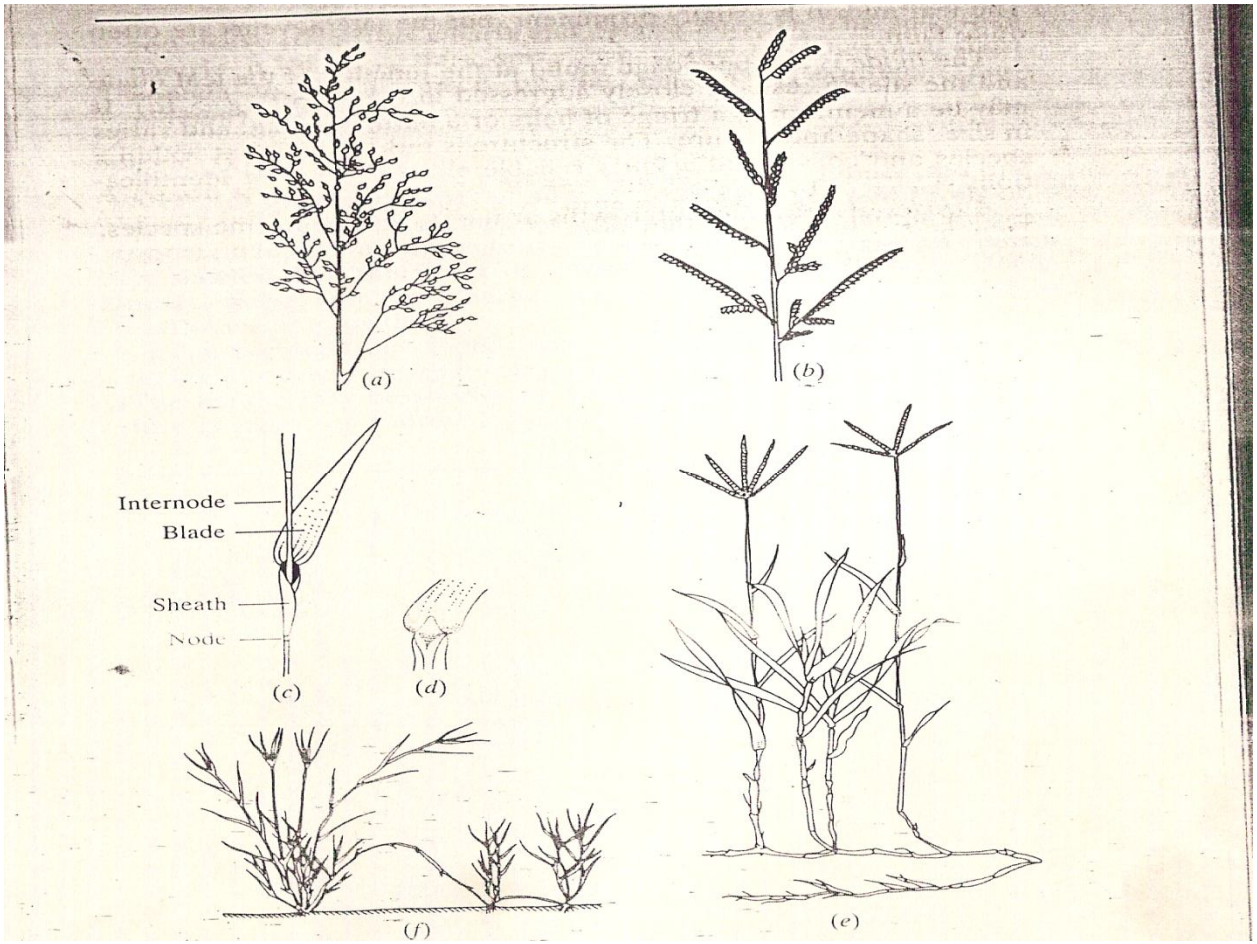
The Leaf blade can be setaceous (wiry and bristle) or filiform (thread-like). The midrib is usually prominent with faint lateral veins.

LIGULE is an appendage found at the junction of the leaf blade and the sheath, usually closely ad pressed to the culm. It may be a membrane, a fringe of hairs or a hardened ring and varies in size, shape and texture, can be used for identification.

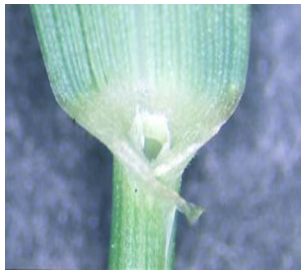
AURICLES are earlike outgrowths at the leaf base of some spp. They can be prominent and encircle the stem, minute and inconspicuous or absent, no chlorophyll, no function, but use in taxonomic identification.

COLLAR: marks the junction of the outer surface (upper region) of the sheath and leaf blade, usually discoloured, leaves breaks at the collar.

PROPHYLLUM: is a two-keeled organ (a reduced leaf) covering the bud in the axil of the sheath.


(a)
(b)
Internode
Blade
Sheath
Node
(c)
(d)
(e)
(f)

Auricles



Present

Blunt

Absent

Ligule

Absent

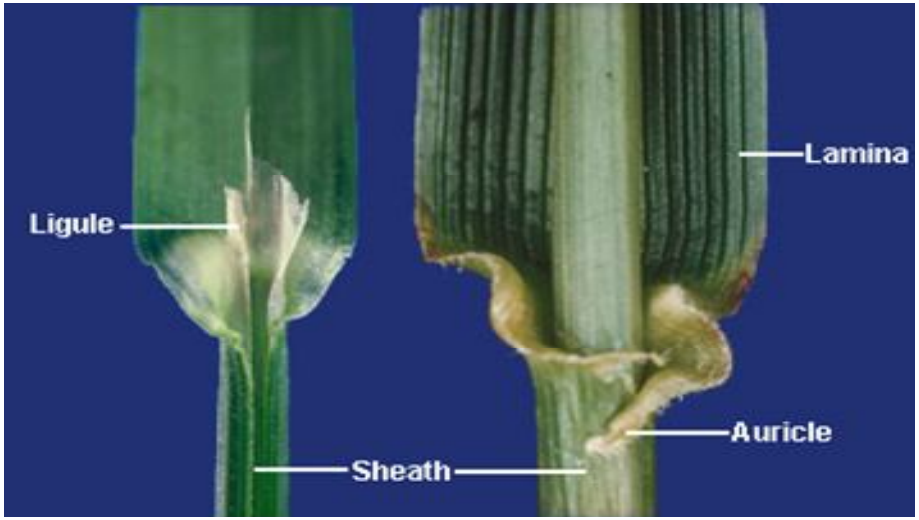
Membranous

Sheath

- Fused or overlapping

Fused

Overlapping



2. SUBTERRANEAN PARTS

Roots appear first from the germinating seed and are known as the PRIMARY ROOTS. Primary roots can branch and provide seedlings with water and mineral nutrients in the first stage of growth. They are then replaced with secondary roots which can be very numerous, which helps retain soil particles to prevent erosion. SECONDARY OR ADVENTITIOUS ROOTS are those that developed from the nodes of tillers or creeping stems.

B. REPRODUCTIVE ORGANS

The Floral Organs are MODIFIED SHOOTS, consisting of STAMENS and PISTILS. The floral organs are called inflorescence.

INFLORESCENCE: The flowers or inflorescences may be terminal, or axillary. The basic unit of the inflorescence is the SPIKELET, which consists of flowers usually occurring in groups or clusters.

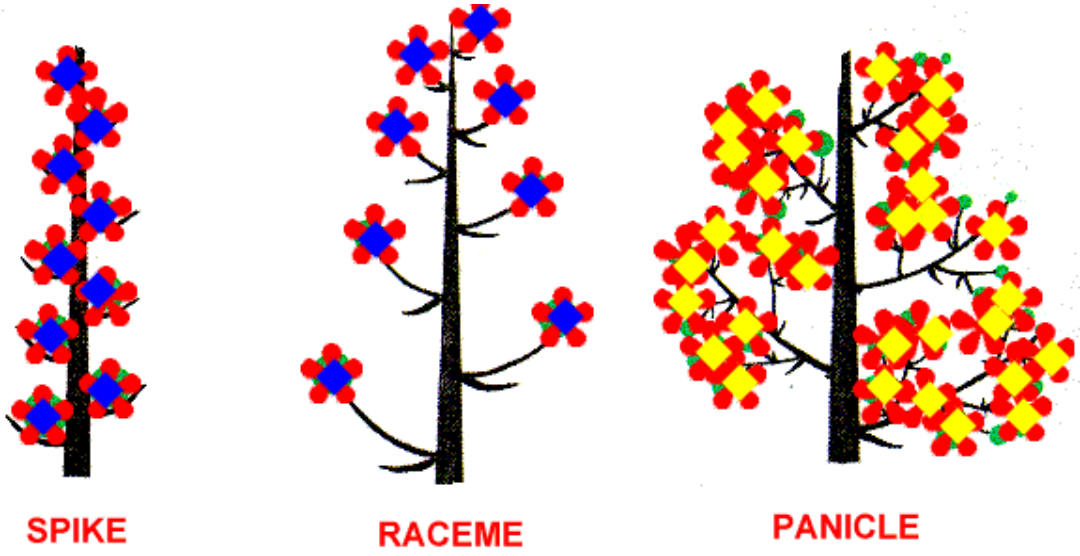
SPIKELET: A typical spikelet consists of an axis (rachilla), two glumes and one to many florets. The perfectly developed floret has a lemma and a palea (lower and upper bracts, respectively) which enclose the flower. The structure of the lamina is such that it provides protection for the seeds and perhaps means of dispersal. The palea is shorter than the lemma and thinner.

Inflorescence types are classified as:

1. SPIKE: the spikelets are sessile (without stalks) or nearly so, on an UNBRANCHED axis (rachis) eg. Lolium, Triticum, Secale, Hordeum, Agropyron or be ONE-SIDED eg. Ctenium elegans or DIGITATE (finger like) as in Chloris and Cynodon Spp. or RACEMOSE on a central axis as in Dactyloctenium and Leptochloa spp.

2. RACEME: spikelets have pedicels along the axis, eg. Digitaria, Paspalum and Brachiaria spp. Racemes are more frequent than spikes.

3. PANICLE: spikelets have short stalks on a branched inflorescence with a central axis and a number of side branches. The panicle may be open and loose (*Panicum maximum*), contracted (*Sporobolus* and *Sorghum* spp.) or spike-like and dense (*Cenchrus ciliaris and Setaria anceps*) or 'false-spike' when the branches of spike-like panicle are concealed by the spikelets (*Pennisetum purpureum*).



THE FLOWER

The floral organs consists of the gynoecium (female parts), androecium consists of three or one to six, stamens. Each stamen has a slender filament supporting a two celled slender filament supporting a two-celled anther, which consists of the pollen grains. Anther are coloured yellow, purple reddish or may be mottled.

The lodicules base of the flower, outside the stamens. The flowers of most grasses are perfect (hermaphrodite) i.e the florets have both stamens and pistils except members of the tribe maydese. *Zea mays*-male and female separated on the same plant.

ture is such

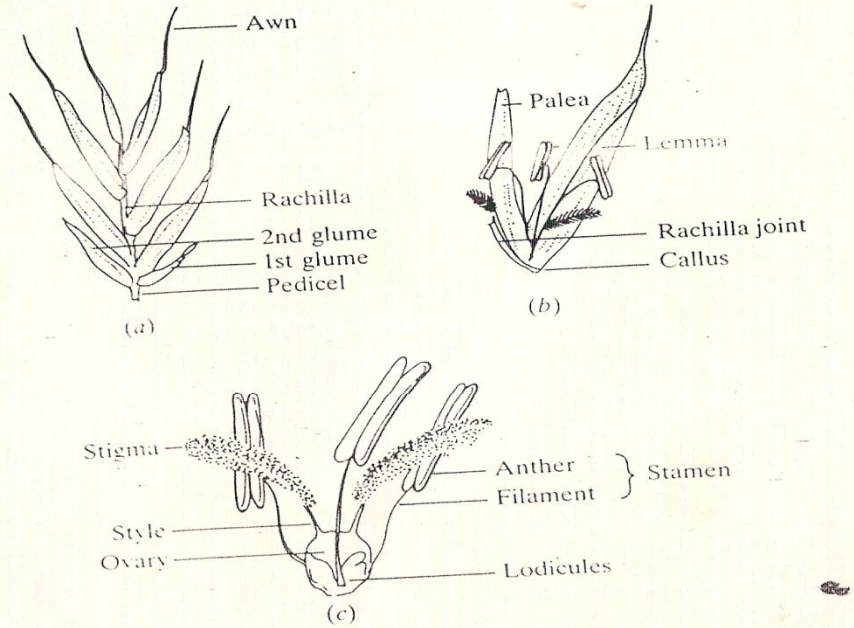
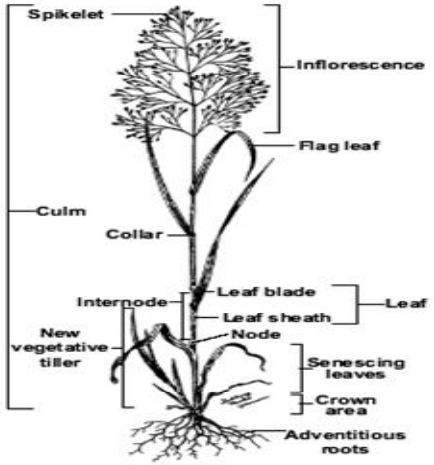


Fig. 3.2 Flowering of the grass plant: (*a*) Spikelet showing arrangement of florets: (*b*) Floret opening at blooming time; (*c*) Typical grass flower showing essential reproductive organs.

Grass plant



BOTANY OF LEGUMES

Legumes are dicotyledonous, i.e. the embryo consists of two cotyledons or seed- leaves). The legume family is sometimes divided into three groups or subfamilies: Mimosoideae, woody plants and herbs with regular flowers, caesalpinoideae, plants with irregular flowers; papilionaceae, herbaceous and woody plants with a distinctive papilionate or butterfly shaped flower. Most of the forage and economically important legumes belongs to papilionaceae family. Legumes may be annuals, biennials or perennials.

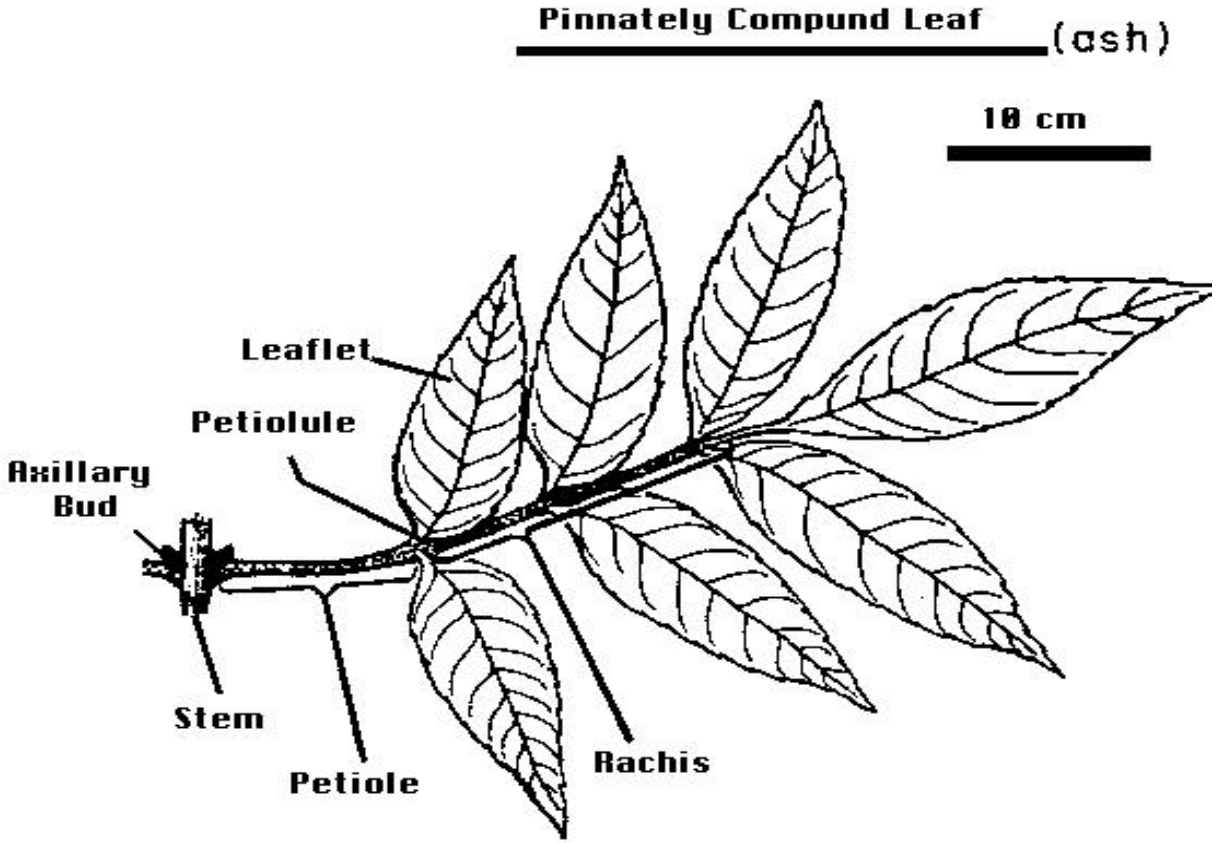
A. **Vegetative organs**

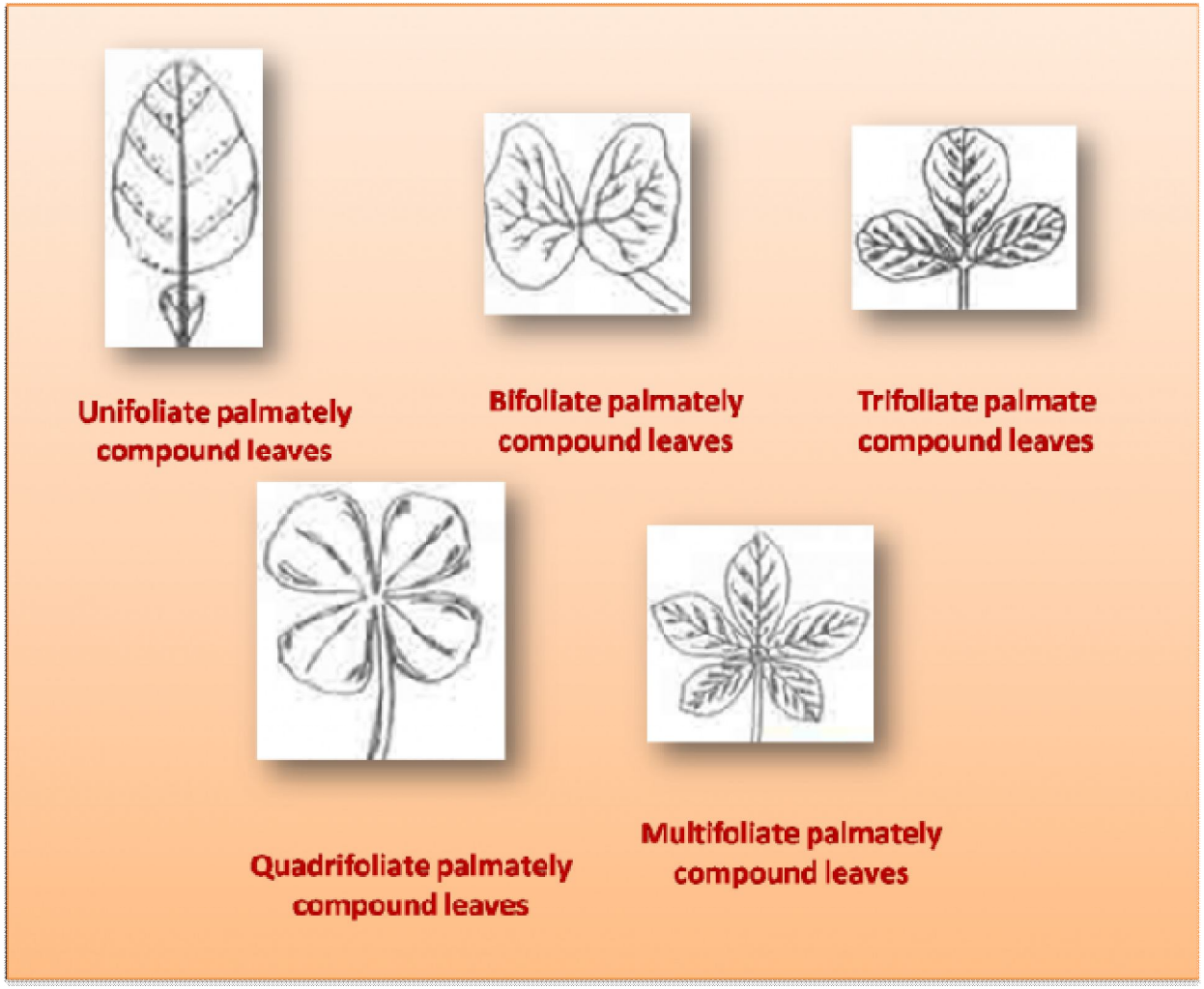
1. Aerial parts

There are distinct morphological differences among the legumes but general characteristics of some plant are similar and rather uniform. The above ground portion consists of a main stem with axillary branches, usually compound leaves, stipules and inflorescences. Tillers sometimes arise from the basal portion of the stem (crown) and stems also develop axillary branches. The stems are jointed, with nodes and internodes, and are usually hollow, except at the nodes. They may be covered with hairs or may be glabrous. Herbaceous stems contains chlorophyll. The leaves contains a common leaf stalk (petiole), with 3 or more leaflets, each with its own stalk (petiolule). The leaves could be 'palmately' compound i. e leaflets directly attached to the end of the petiole e.g. *Centrosema pubescense* or' pinnately'

Compound when the petiole extends into a long slender structure with leaflets e.g. *Clitoria ternatea.* Some have leaflets modified to tendrils e.g. *Lathyrus spp.* Presence of *pulvinus* is the characteristic feature of legume family.

Stipules are leaf-like outgrowths found at the base of the main leaf stalk, vary in shape and size and used for identification of species. The leaflets and stipules may be smooth or possess hairs. The veins on the leaves are netted pattern unlike parallel venation of grasses.


Pinnately Compund Leaf (ash)
10 cm
Leaflet
Petiolule
Axillary Bud
Stem
Petiole
Rachis



2. Subterranean parts

The roots system of most legumes consists principally of an actively growing primary roots and its branches (secondary). The primary roots may penetrate the soil to a depth of 6-8m e. g Lucerne. The roots of many leguminous plants become infected by bacteria of the species Rhizobium, Which grows and multiply, forming nodules which differ in size, shape and arrangement on the roots.

B. Reproductive organs

Inflorescence

The Mimosoideae produces flowers in dense heads or small globular, spike – like inflorescences, and commonly has the floral parts arranged in the sets of four, They are rendered conspicuous by the long, coloured filaments of the numerous stamens. e. g *Leucaena leucocephala* and *Acacia spp.*

The caesalpinoideae flowers appears in clusters or racemes, with overlapping petals .The stamens are usually separated e. g *cassia spp., Ceratonia spp. and Gleditschia.*

The flowers of papilionaceae are arranged in racemes as in *Desmodium spp.* in heads as in T*rifolium spp.* or spike-like racemes as in *Medicago sativa*. There is a central axis, along with the individual flowers develop. Each flower has its own short stalk or peduncle. The inflorescence may be terminal or auxiliary.

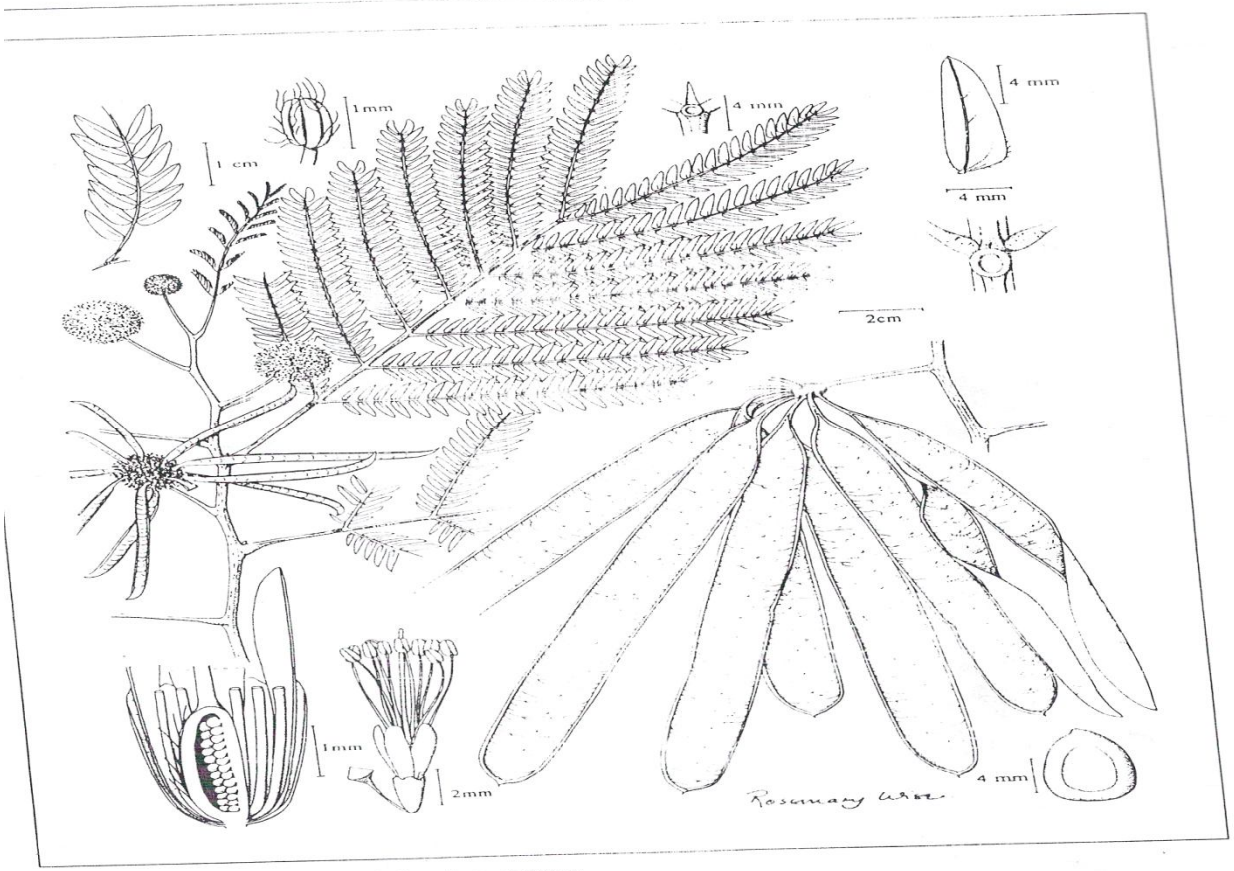
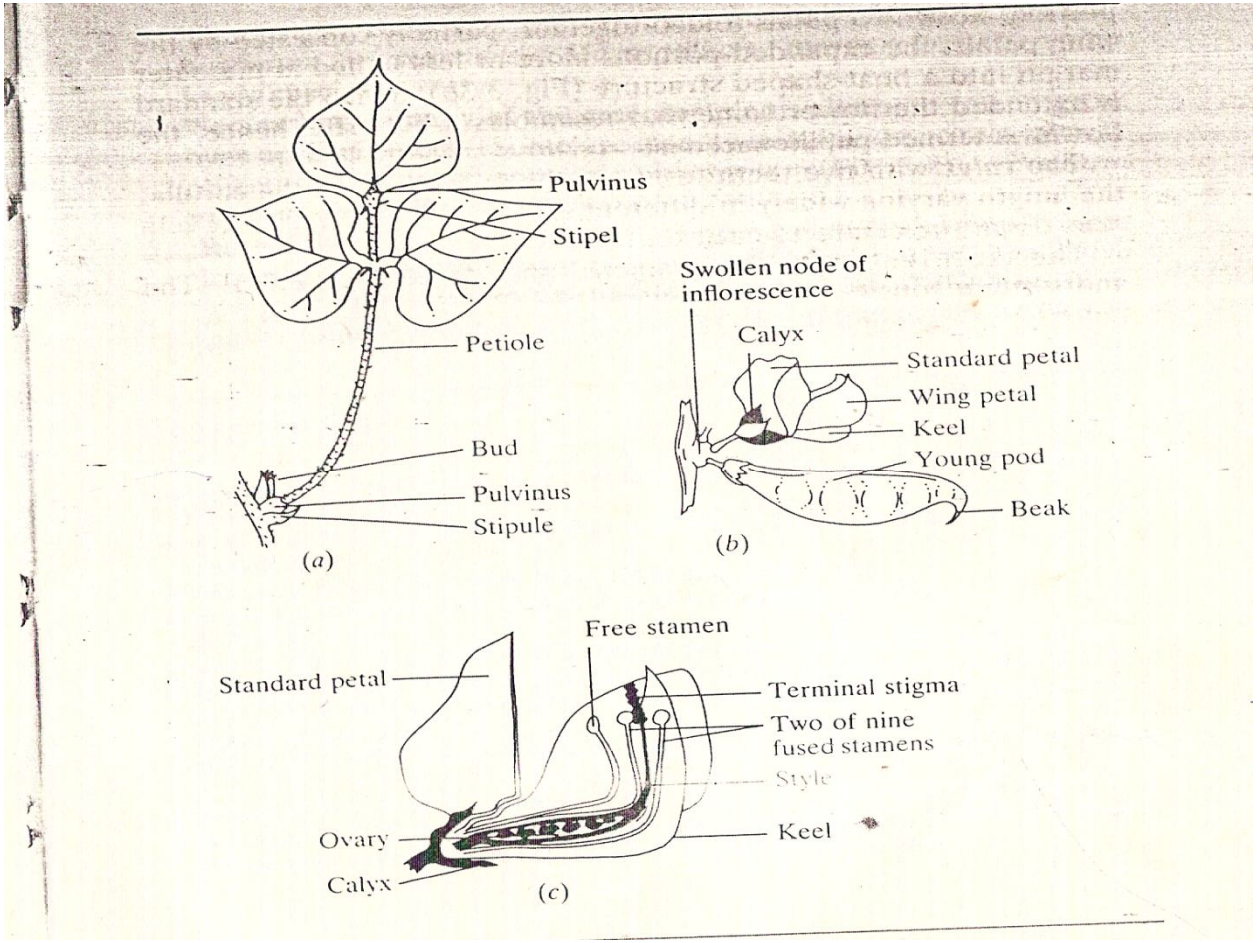


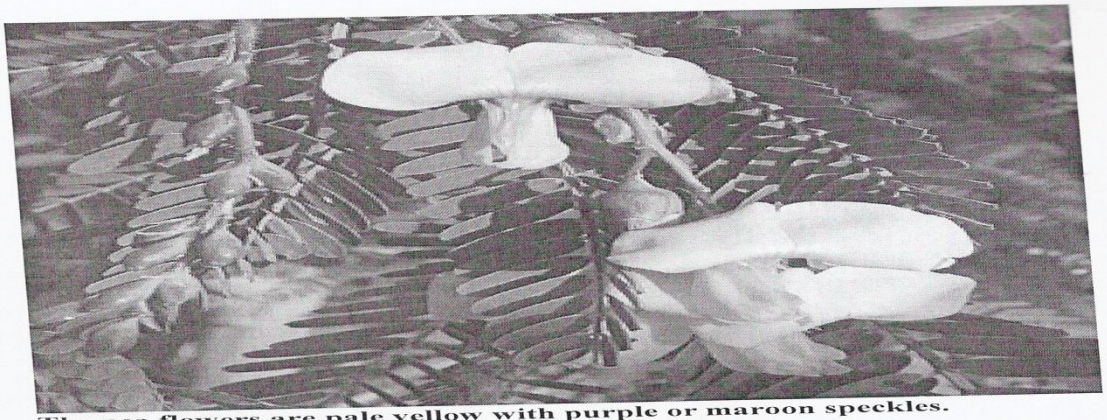
Figure 42 *Leucaena leucocephala* subsp. *glabrata*

The flower

The corolla consists of five petals of three distinct kinds : ‘standards’ or ‘banner’ uppermost or outer petal, largest and most showy; two wing petals, with slender stalks called the claw , and an expanded portion; keel, two petals folded together, partially concealed by the wing petals, the expanded portions more or less united at the outer margin into a boat-shaped structure.

The calyx with five teeth forms a tube at the base of the corolla. The keel encloses the stamens and pistil .The androecium consists of the ten stamens, the filaments of which may be united. The Staminal tube surrounds a superior ovary, an elongated structure comprising one carpel with one ovule or a single row or several ovules. A bent style surmounts the ovary and the stylar tip broadens into the stigmatic surface. The nectar resides at the bottom of the corolla.


Pulvinus
Stipel
Petiole
Bud
Pulvinus
Stipule
(a)
Swollen node of inflorescence
Calyx
Standard petal
Wing petal
Keel
Young pod
Beak
(b)
Free stamen
Standard petal
Terminal stigma
Two of nine fused stamens
Style
Ovary
Keel
Calyx
(c)



The pea flowers are pale yellow with purple or maroon speckles.
Photo by R. P. Ellis courtesy Ecoport
(source URL: http://www.ecoport.org)

Habit. A soft wooded tree up to 6 m tall.
Photo by R. P. Ellis courtesy Ecoport

Fruit and Seed

The ripened ovary forms a fruit of variable shape, called legume or pod. Some seeds shatters – dehiscent e. g *Macroptilium atropurpureum* and *Centrosema pubescens* while some are non-dehiscent e. g *Crotolaria* spp. Pods can the reserve food is stored in the cotyledons. Pods can be glabrous or covered with hairs. Each seeds is enclosed in the testa or seedcoat. Hilum marks place of attachment o the ovary walls. The legume seed has no endosperm.

Growth habit

1. Bush – type – a central stalk with side branches appearing along the main stem and with axillary branches developing *Cajanus cajan*; *Desmodium tortuosum*.

2. Bunch – type- a single crown from which several stems and new tillers arise, making it difficult to identify a main stems, stems can be erect or decumbents e. g. *Stylosanthus guianensis* and *Medicago sativa.*

3. Creeping – the stems trail over the ground surface e,g *Calopogonium mucunoides*, *Macroptilium atropurpureum*, some vigna spp.

4. Scrambling – many of the creeping plants climb onto and grow over upright objects. Some are also twining and encircle upright objects e. g *Centrosema pubescens, Pueraria phaseoloides.*

5. Rosette - a vegetative form of some perennials developed after flowering or the onset of cool weather e. g *Medicago sativa* and *Trifolium pratense* at the higher elevations of the tropics.

SYSTEMATICS OF PASTURE PLANTS

Gramineae (grass family) and leguminoseae (legume family) are divided into lower or minor categories of the tribes, genera and spp. (Lawrence, 1951)

Tribes are group with certain phylogenetic (evolutionary) relationships.

A genus comprises of plants with common reproductive structures. Which extends beyond morphological differences to genetics, cytologic, physiologic, ecologic and geographic relationships.

The generic name of a plant is the first of the words making up the botanical binominal e. g *Chloris gayana.*

Species consists of a natural population of plants with common morphological characteristics (phenotypically similar), having a common ancestry and capable of replacing like types (Lawrence 1951) it is identified taxonomical by the secondary name of the binominal used as a scientific name. this group is the most important botanical unit for the pasture agronomist and cattleman, since plants of species may have broad adaptability to diverse soil and climatic.

The species is a particular interest to the plant breeder, who brings together introductions of the species from different sources and searches for the type which excel in adaptation, herbage yield, persistent e.t.c which may be released as cultivars e. g *Chloris gayana* 'Masaba'.

'varieties' are morphological variants and subdivisions of the species. In botanical literature, they will be written with the specific name e. g *Panicum maximum var. Ntchisi, Imperata cylindrical* var. africana to distinguish it from those of other area. It can refer to plant population of the same species which differs from another one in one or more recognizable inherited characteristics.

'Cultivars' is the internationally recognizable term for the agricultural variety. A cultivar is a cultivated population of plants with recognized, morphological, physiological, chemical or other differences. They may follow generic, specific or common names e.*g Desmodium* Greenleaf. *Desmodium intortum* Greenleaf or *desmodium Greenleaf*.

Ways of classification

The earliest system of classification were based on pre selected characteristics, such as form or habit e.g. trees, shrubs, herbs, annuals, biennials, perennials.

Carolus Linnaeus(1707-1778) a Swedish, revolutionised plant classification through sexual system of flora characteristics especially stamens and pistils.

But attention is now on microscopic and submicoscopic features of spines, hairs, spores, pollen grains, starch grains, cellular inclusions e.t.c.

Later knowledge of cytology in determining chromosome number, size and morphology, behaviour and structure in meiosis led to establishing cytotaxonomic relationships.

-Biochemical properties of plants have been studied to been studied and used by taxonomists, for a long time e.g essential oils, pigments, alkoids, flavonoids, glycosides, and non protein free amino acids, which is chemotaxonomy.

-Immunological studies of proteins yields measures of taxonomic relationship. The implications of each development is that plants are always reclassified but this does not alter plant adaptability and response to management practices.

Nomenclature

Scientific names (botanical or Latin names) may be long, unfamiliar or difficult to pronounce but it has the following advantages:

1. Same names used in all languages.

2. Uniform binomial (two names)

3. Binomials are exact in delineating a species.

4. Descriptive (for those versed in Greek and Latin)

5. The choice of names is governed by international rules of botanical nomenclature

Common names (called vernacular, colloquial, folk names) it depends on language of a place and descriptive (sword bean, lemon grass-*Cymbopogon flexuosus*) or bear name of a person (Rhodes grass-*Chloris gayana*), location (Townsville stylo-*Stylosanthes humilis*) or associated with a habitat (beach grass-*Ammophila spp*).

May refer to genus e. g desmodium. Its use can be confusing and misleading.

1. Restricted to one language or dialect, and perhaps to one locality.

2. Names are indefinite

3. Are not regulated by a constituted authority.

Classification and distribution

Classification of Grasses

Graminae (Poaceae) is a large botanical family with about 10,000 spp. grouped into some 650 genera and genera into 50-60 tribes; with sub families of 2 to 12.

3 group are of interest- Festucoid group-temperate grasses; Panicoid group- tropical and subtropical and Chloricoid group- few tropical cultivated and a number of valuable wild grasses the tropical and warmer areas of North American .

Examples of festucoid- Tribes of Triticae (Agropyron spp) Festuceae (Festuca, Dactylis, Lolium, poa) Bromeae (Bromus), Aveneae (Avena,Arrhenetherum) Agrostideae (Agrostis, Alopecurus, Phleum)

Panicoid- Paniceae or mellinidae (*Panicum*, *Brachiaria, Digitaria, Mellinis*, Pennisetum, Cenchrus), Andropogoneae (Andropogon, Hyparrhenia, Sorghum, Lasiurus, Themedia) and Maideae (Zea, Euchlaena, Tripsacum)

Chloridoid- chlorideae (Chloris, Cynodon) and Eragrosteae (Eragrostis, Dactyloctenium, Eleusine)

Classification of Legume

Order- Leguminosae (Fabaceae) family is divided into three distinct groups or families- Mimosoideae, Caesalpinoideae, Papilionoideae and subfamilies- Mimosaceae, Caesalpinaceae and Papilionaceae of the botanical order Leguminosae.

Only two spp of mimosoideae are important to us – *Leucaena leucocephala* and *Desmanthus virgatus*, although a number of shrubs and trees are browse plant of Acacia spp.

A number of Caesalpiniodeae are cultivated for fodder and only very few are used as natural browse plants.

Species of Papilionoideae are widely grown as pasture or fodder crops and are of considerable important for natural grazing or browsing. It is a large subfamily with 200 genera and some 12,000 spp. distributed throughout the world.

Leguminosae in general are of tropical origin with Caesalpinaceae as the most primitive type .

17 tribes of Papilionoideae are recognized. With important ones as Indigofera, Aeschynomeneae, Sesbanieae, Genisteae, Psoraleae and Trifolieae but majority of legume in cultivation belongs to the tribes – Stylosantheae, Desmodieae and Phaseoleae. The above tribes especially the last three are distributed all over the world, with Desmodieae and Phaseoleae concentrated in Latin American.

Centre of distribution

TROPICAL GRASSES

1. East Africa- species of *Brachiaria, Cenchrus, Chloris, Cynodon, Panicum, Setaria,* and *Urochloa.*

2. South Africa- species of Digitaria and urochloa

3. Arabia, Pakistan, and Northern India – *Cenchrus*

4. Subtropical South American- *Axonopus, Bromus, Paspalum and Sorghum*

TROPICAL LEGUMES

1. Centres of high species density exist in Central America, Bolivia, Southern Brazil, and Paraguay- *Macroptilium, Desmodium and Leucaena*

2. Central and Southern American- *Centrosema, and Stylosanthes*

3. East Africa – *Glycine and Macrotyloma spp*

4. Southern African- *Lotononis*

5. Southern-East-Asia-*Pueraria, Vigna, Calopogonium,*

PASTURE IMPROVEMENT PROGRAMMES AND BREEDING

Pasture improvement and development programmes may be initiated through a number of different approaches.

1. The first approach is based on improved management and utilization of existing natural pasture resources.

2. The second approach is to replace existing natural vegetation with introduced pasture species.

3. While a third method is a combination approach, where an introduced species may be over sown into existing native pasture.

The basic philosophy is that the existing species in the region are well adapted to the environment and research and management seeks to increase or at least maintain the most productive species for animal production.

Improvement of grassland takes many forms. 1. stock control and controlled grazing, and this has often led to a change in botanical composition without the deliberate introduction of new species.

2. casual or deliberate introduction of legumes, notably in Australia, and this has been linked with the recognition and correction of major and trace element deficiencies, particularly phosphorus and molybdenum.

3. A further stage of improvement is reached when new grass species are introduced deliberately, often with and an accompanying legume, with or without the destruction of indigenous grasses.

Selection of species or cultivars for improvement.

In selecting a new grass or legume; or in replacing an older one with and improved cultivars of the same species; the following points should be considered:

A. Characters required in the pasture plants. The species or cultivar characteristics are important. They are: 1. High yield of good quality forage and re-growth potential.

2. Ease of establishment or propagation.

3. Palatability

4. Length of vegetative stage of growth

5. Response to applied fertilizers

6. Persistency

7. Tolerance to drought, grazing, cutting and burning

8. Seeding habit

9. Ease of eradication

10. Ability to associate with other species.

B. Other points are:

1. Adaptation – to the general region and local conditions

2. Intended use – continuous or rotational grazing, hay, silage, green chop, rotation grazing, soiling.

3. Availability of seed or planting material

4. Value of land-especially if the new grazing land is to be intensively used

5. Topography of land –mechanizable or steep

6. Type or quality of animals to be grazed or fed

7. Managerial skills of cattleman

Approaches to plant introduction

1. Through correspondence with other research institution or agencies

2. Evaluation of existing species and cultivars by major institutions in regions with similar environmental conditions

3. Assess the climatic comparisons or the phytogeographical distribution of species in the areas.

Organization of plant introduction

Plant introduction group has a number of functions, the basic ones are:

Acquire new plant accession and organize their introduction into the country

Organize the documentation of all introductions

Provide initial screening, description, and evaluation

Build up seed stocks and planting materials and to maintain seed stocks for future testing or breeding programmes

In larger organizations, will be involved in toxonomic studies, phytogeographical studies of species distribution, and plant collecting expeditions.

Primary evaluation stage –

1. Provide a quarantine check of introductions

2. Build up seed stocks or vegetative planting materials

3. Describe the morphology, phenology and growth Characteristics of the accession.

Records kept throughout the growing season must include: Growth habit, Leafiness, Vigour, Time of flowering- length of flowering period

- Seed set- amount harvested
- Effect of low or high temperatures
- Regeneration

- Incidence of pests and diseases
- Nodulation in the case of legumes
- Second stage of evaluations aimed to examine the agronomic characteristics under field sward conditions
- - Competition
- -Stress
- -Productivity
- -Vigour of the sward- through estimation of botanical composition
- -Persistence- plant counts at establishment and subsequent survival
- -Potential feeding value- *in*-vitro digestibility studies, intake studies with penned sheep.

Scheme of pasture and forage crop characterization (adapted from Mott and Morr, 1969)

1.	Introduction	Observation Selection	Breeders lines
2.	Small plot clipping	Varietal tests Chemical analyses *in-vitro* digestibility Regional tests	Advance selection

3.	Agronomic Management	Sowing densities Fertilizer studies Grass-Legume Cutting treatments	Cultivars
4.	Animal Response	*in-vitro* digestibility *in- vivo* digestibility Stocking rate	Product per animal Economic Returns
5.	Feeding Systems	Pasture sequences Hay and silage Supplementary feeds	Animal Outputs Economic Returns

METHODS OF PROPAGATION

Tropical grasses are established vegetatively or from seed. Vegetative propagation can be used if it is simple or cheaper, or when the purity and uniformity of hybrid clones or clones of cross-polluting grasses should be maintained as example in clone cultivars or hybrids of Bermuda grass(*Cynodon dactylon*).

Stoloniferous and rhizomatous species can be propagated by pieces of stolons or rhizomes spread on the ground and buried in by subsequent harrowing or discing. Large tufted grasses, such as elephant grass (*Pennisetum purpureum*), *Tripsacum laxum*, large varieties of *Panicum maximum* etc are planted in rows by splits or sprigs.

When planting, the top portions of grass should be cut off as the splits with uncut stems and leaves would almost invariably die because of the loss of water through the leaves. Long roots should also be cut short because the old rots would any how die out and the plants develop new roots and live on them. It is advisable to pile the splits loosely, water the pile and cover them with sacks for a few days, until the new roots begin to appear. Planting is normally done in rows the distance between the rows depending on plant

size and local custom; Planting is done by hand or by special machines as those for planting sugar cane or adapted for tobacco planters. Elephant grass is normally planted by stem cutting; the stem should not be very young and cut to pieces each having about three nodes. The stems are stuck into the soil with two nodes underground. Establishment from seed is usually more difficult in the tropics than under temperate conditions because:

1. Seeds are often not in ready supply

2. Mostly small

3. Drought can kill small weak seedlings

4. A clean, not too fine seedbed as free from weeds as possible should be prepared

5. Seed is then broadcast or drilled in rows.

Seed rates vary and can be recommended with some certainty only if the quality of seeds i.e. its purity and germination is known. Seed quality can be expressed as percentages of PGS (pure germinating seed), PVS (pure variable seed) or PLS (pure live seed). It can generally recommended not to plant seed immediately after harvesting but after some six months of storage, but seeds stored for 2 or more years should be re-examined for germinability.

Fertilizers are given before, during and after sowing; phosphorus in form of double or single super phosphate is usually given before and during the sowing; N is given in its nitrate form, ammonium form or as urea. Time of application is a controversial issue; some recommend about the sowing time and some during the dry season to be released at onset of rains. Nitrogen is often applied after each grazing or cutting.

If weeds are a problem, the early management includes mowing before the weeds get to flowering stage, at a time when grass plants are still weak and this may reduce grass-weed competition and result in a better establishment; if the weeds include palatable species, early grazing can replace or supplement mowing.

LEGUMES: are established almost exclusively from seed although growing some creeping species from roots cuttings had been attempted and in perennial species of *Arachis*, this is a normal method of establishment.

Stem cutting of a number of perennial leguminous species can root and produce vegetative progenies of cross-pollinated plants, for examining the effects of environment on genetically identical material, etc.

Seed bed- for farm sowing is prepared in the usual way and seed is sown preferably in rows, especially in grass/legume mixtures in which the two components are often sown in alternate rows.

Seed rates differ widely depending mainly on seed size: the number of seeds/kg ranging from 2-2.5 thousand in species of *Mucuna* to over 3million in *Lotononis bainesii*.

Similarly considerable proportion of hard seeds i.e. seeds which remain viable in the soil for months to several years without germination. The presence of hard seed is normally an inheritable character, it can be reduced by selection and in species or cultivars grown for a number of generations, the percentage of hard seed is usually negligible; on the other hand it can be very considerable, especially in recently introduced species. The presence of hard seeds is apparently an adaptive feature which prevents all seeds from germination at the first opportunity and then dies if a sudden drought occurs.

Water cannot penetrate through the seed skin or testa of hard seeds and remain un imbibed .

Methods of removing hard seed

1. Soaking in water for some 24hours or longer can reduce the proportion of hard seeds but the reduction is relatively small.

2. Mechanical scarification (seed scratching)

-using hammer mill

-Rubbing seeds with and paper if the amount to be treated is small.

3. Soaking in concentration Sulphuric acid is perhaps more reliable and efficient method of reducing the percentage of hard seed, duration of time take 2 to 20- 25minutes to determine experimentally. Then thoroughly wash with water.

Hard seed should be treated before inoculation with Rhizobium, if seed is inoculated it should be sown as soon as possible after the inoculation but delays in sowing are much less harmful if seed has been pelleted, Rhizobium bacteria of the Cowpea group lose their

ability to grow and can die at a temperature of 400c and above, during or after sowing, Hot weather is harmful to Rhizobium inoculated small seeds which require shallow sowing.

Fertilizers used for the legumes include mainly phosphorus in the form of double or single super phosphate; the latter is preferred as it contains Sulphur, the deficiency of which can be reducing the vigor and productivity of the legume. Potassium is another nutrient commonly used as fertilizer. The legumes are sensitive to deficient in micronutrient and Molybdenum is particularly important for Rhizome activity. On soil deficiency in boron and copper these nutrients have to be added. The tolerance of legume to Aluminum and Manganese varies. *Stylosanthus humilis* and *Lotononis bainesii* are more tolerant then many others.

PHYSIOLOGY OF PASTURE PLANTS

The majority of tropical grasses are either indifferent to day length (*Tripsacum dactyloides*, *Acroceras macrum*) or are short day plants and flower earlier under short than long photoperiods (*Hyparrhenia hirta, Sorghum halepense*); there are however, tropical spp (*Paspalum dilatatum*) which flower easier and earlier under longer than shorter photoperiods.

Herbage production follow the pattern of flowering but in the majority of grasses long photo periods stimulate herbage growth and production.

For temperate grasses, the productivity of photosynthesis in terms of amounts of synthesis organic matter increases with the increase in light intensity up to 15,000- 25,000 lux above which, productivity of photosynthesis do not increase further.

However, in tropical grasses, photosynthetic productivity increases further and reaches it maximum at 50,000-60,000 lux and sometimes even at higher light intensity, and can be much greater than in temperate grasses provided that light intensity is sufficiently high. The tropical grasses that response in the above way to light intensity belong to the tribes- Panicoid and Chloridiod. While, Festucoid grsses differs and the above differences can be linked with leaf anatomy. In Panicoid and Chloridiod grasses, the cells are known as Kranz-type cells while those of Festucoid are known as non-Kranz cells. In Festucoid grasses, the photosynthetic process is of the so-called Calvin or C3 cycle while that of Panicoid and Chloridiod is known as C4 pathway. In C3 cycle, the initial products of Carbon assimilation are 3-phosphoglyceric(3-carbon) acids or hexosphosphates are further utilized for formation of

carbohydrates with optimum temperatures of 15-20^{o}C while for C4, the initial products of photosynthesis are 4carbon acids- malate, asparagate, oxalo-acetate with optimum temperature of 30-40^{o}C.

Grasses tend to be more aggressive than legume in mixture due to the differences in their photosynthetic pathways. Most tropical grasses are C4 plants while the legumes are C3 plants. Hence grasses utilises sunlight energy better than legumes which leads to higher structural carbohydrate formation and this forms the reason grasses are higher in fibre than legumes.

The importance of legumes in agriculture as arable fodder and pasture crops and as components of natural grasslands and perhaps also their wide spread throughout the world depends as it is universally known on their ability to fix atmospheric nitrogen in symbiosis with rhizobium bacteria found in the legume root. Some rhizobium bacteria are highly specialized and can enter into symbiotic relationship only with certain species of legume; some are less selective and live and work actively in a few species, usually closely phylogenetically related and there are also promiscuous or indiscriminating bacteria which can innoculate a large number of species which belong to the so called cowpea type; they can be in an active symbiosis with a number of tropical legumes, one widely spread in poor and acid soils of the tropics and conversely, most of the tropical legumes can be inoculated and the same cowpea rhizobium. There are not much differences in the physiology of legumes and they adapt to lots of climatic conditions. Rainfall is the only major climatic factor affecting legumes in the tropics while temperature can have effects on temperate legumes.

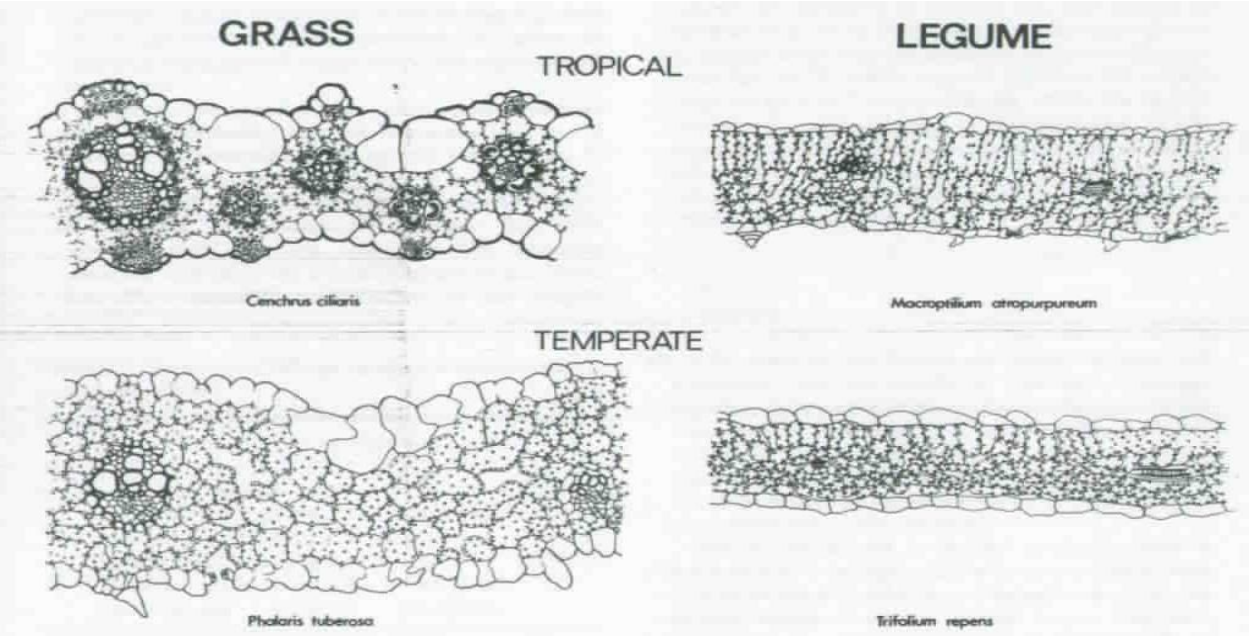


Fig. 6.2. Cross-sections of laminae of a tropical C_4 grass (*Cenchrus ciliaris*), a tropical C_3 legume *Macroptilium atropurpureum*, a temperate C_3 grass (*Phalaris aquatica* formerly *P. tuberosa*) and a temperate C_3 legume (*Trifolium repens*) showing different proportions of vascular tissue. (Photo: J. R. Wilson.)

TROPICAL CLIMATE AND IMPLICATION ON PASTURE PRODUCTION

The extremes of wet and dry, hot and cold, daily downpours and extended drought, fertile flood plains and eroded overgrazed hills, steaming lowlands and permanent snowclad peaks, along with other inconsistencies of nature make up the tropical environment.

These elements- climate, vegetation and soils- are its most essential components. Climate is the dominating factor and shapes the vegetation, modifies the soil and ultimately affects all forms of life.

The type and distribution of tropical grasslands are largely determined by climate and its interaction with the soil. Total annual rainfall and its distribution regulate the adaptation, growth and production of grasses, legumes and browse plants, even though

other factors such as temperature, humidity, sunlight, elevation, slope and expose of terrain exert a strong influence, man's activities can have great influence on the environment.

CLIMATE

Climate is made up of a composite of day to day weather conditions. It is an average of weather overtime while weather is a state of the atmosphere with respect to heat or cold, wet or dry, calm or stormy, clear or cloudy. It changes from day to day and variation is influenced by geographical location, topography, distribution of land and water, mountain barriers, altitude, wind, ocean currents and vegetation. The major atmospheric elements making up climates in the tropics are moisture, temperature, light and air movement.

Moisture: Precipitation is the most important climatic element since temperature and light are less likely to be limiting for the growth of plants in the tropics.

Average rainfall and distribution: The total amount of rainfall fluctuates widely from one region or location to another. Average rainfall data are usually of limited value and distribution throughout the year is more meaningful for the agriculturist and the grassland husband man.

Grass and legume adaptation and production are largely determined by the amount and distribution of rainfall. Under all conditions, the distribution of rain determines the pattern of plant growth.

Rainfall intensity: In many parts of the tropics, a high proportion of the rainfall descends in heavy storms of short duration e.g. 50-100mm/h in 5-40mins and generally exceeds that of temperate

Rainfall reliability: Total rainfall fluctuates widely at a given locality. Frequently, the beginning of the rainy season and the onset of the dry season are changeable and vary several weeks or even months. The reliability of annual rainfall can be calculated however by knowing the average annual rainfall and the range over a given number of years.

Effectiveness of precipitation: Percentage of rainfall made available for plant utilization is influenced by the following variables.

1. Evapotranspiration

2. Surface run-off

3. Drainage of rainwater

4. Amount of stored water

Humidity: Moisture in the atmosphere is usually expressed as relative humidity i.e. the percentage of water vapour present given as a percentage of the amount which could be held at saturation. There is increase in fungi problem with high humidity, and this hinder seed production.

Temperature: The tropics and subtropics have percentage that permits plant growth throughout the year except at higher elevations. Seasonal differences occur with greater ranges in the wet-dry and arid climates than in the equatorial humid regions e.g. *Panicum maximum* and *Pennisetum purpureum* thrive well in the hot, lowland tropics but lower herbage yields in more northern latitudes and higher altitudes. *Chloris gayana, Setaria anceps, Desmodium unicinatum* and *Desmodium intortum* flourish at elevations where nights are cooler.

Lights: light is of basic important as the source of energy for the photosynthetic process. The intensity and quality of light varies with the angle of the sun's rays, duration of the light period and atmospheric conditions.

Air movement: movement of air are determined by differences in pressures which are linked with temperature phenomena. The air flow patterns are also modified by friction produced by the earth's surfaces, especially mountain ranges.

Climate and Vegetation

A close relationship exists between vegetation and climate as a consequence of plant evolvement and adaptation over ages of time. A climax plant formation exist and is also called an association and consists of several spp. Classification of climates begins with vegetation rather than climate itself.

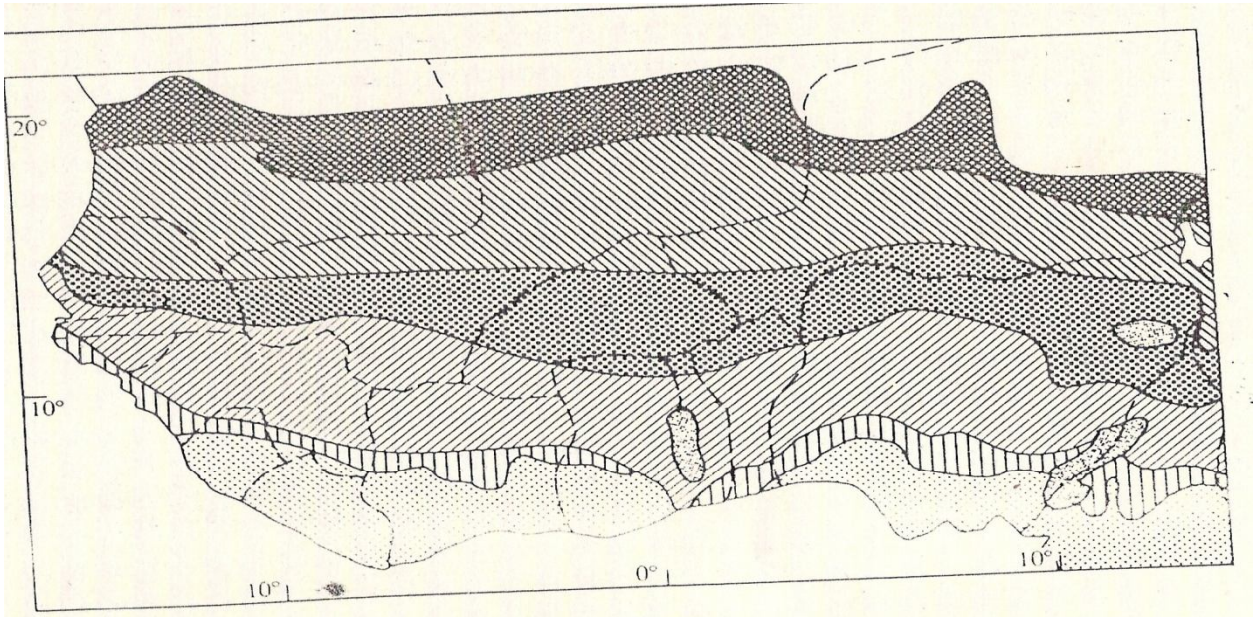
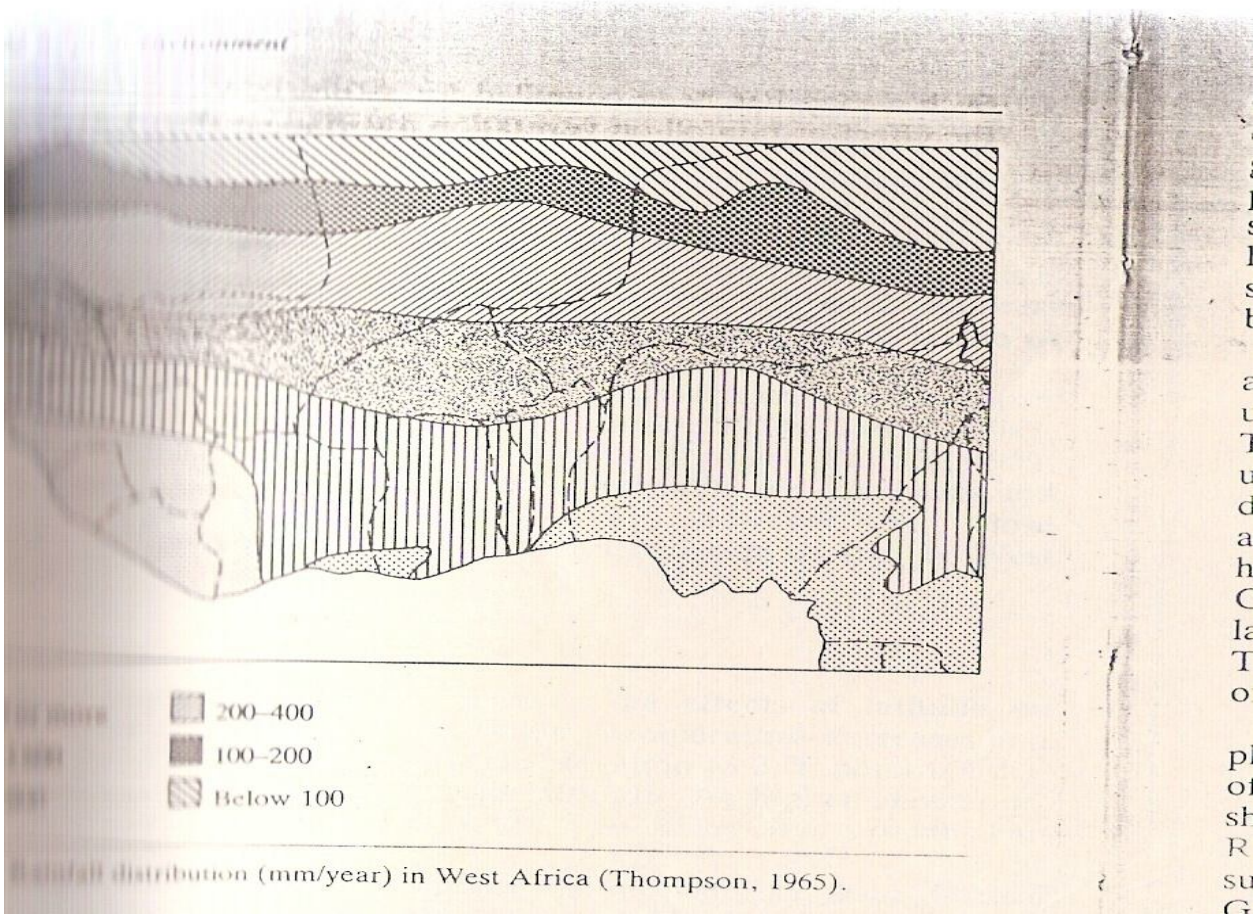
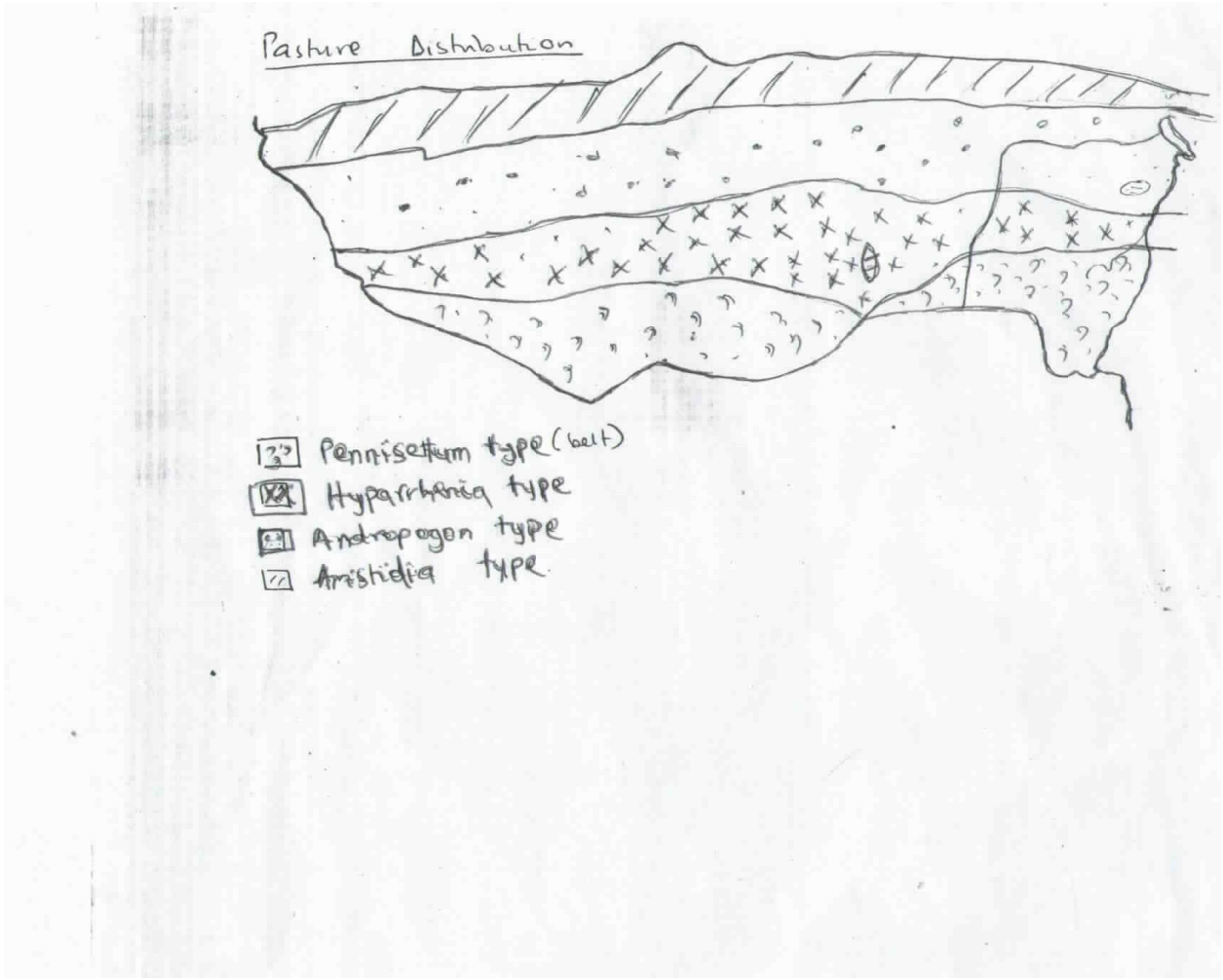


Fig. 1.2 Vegetational zones of West Africa (Keay, 1959): (1)

map (Fig. 1.2) and the rainfall map (Fig. 1.3) o



distribution (mm/year) in West Africa (Thompson, 1965).



From rainfall distribution (mm/year) in West Africa (Thompson,1965), four of the main vegetational zones are commonly called savannas and are recognized as climatic regions representing different agricultural interest. Their boundaries are in part related to those delineated by the type of genera of the grass distribution, namely:

1. *Pennisetum* type- lowland forest and derived savanna

2. *Hyparrhenia* type- Southern Guinea savanna

3. *Andropogon* type- Sahel and part of Sudan savanna

4. *Aristidia* type- Sub-Saharan

Near the coast there is no distinguishable dry period and the region is classified tropical rainforest and swamps. Over much of the zone, two peaks of rainfall alternate with two dry seasons. A layer drought period prevails from October or November to March or April and a shorter one occurs in July or August.

The forests are broken vertically with 2 or 3 layers of trees, the tallest storey emerging at more than 30m. Tall coarse grasses appear in the more open lands of the forests. A semi deciduous forest exists of the trees has been cleared for cultivated and where the dry season ranges from 3-5months.

The derived savanna merges into two woodland savannas' which are separated on the basis of moisture and vegetational core. The 'humid savanna' (Guinea savanna) is characterized by 5-7 months of dry season, usually continuous.

Rainfall varies from about 1,000 to just less than 1,500mm the area is largely woodland with fire-resistant, broadleaved deciduous trees. The canopy may be full or open at 15-20m. Tall perennial tufted grasses grow up to 3m beneath the scattered trees and up to 5m open places. Since, the cattle population is relatively sparse, a heavy growth of grass accumulates by the end of the rainy season. Always widespread fires rage beyond control.

The 'dry woodland savanna' (Sudan) receives from 500-800mm annual rainfall with 7-9 months having 100mm total. The region is wooded but many single trees occur and display wide, spreading crowns and small leaves. The trees grow from 10-15m height and shorter than in the humid savanna, there are many leaves growing shrubs and bushes in the southern areas. Thorn bushes are prevalent in the northern part of the dry savanna. Grass cover is shorter than in the humid savanna, from 1.5m to just over 3.0m in height when matured, less tufted, more feathering with finer leaves and stems, and fewer perennials. Much of the area is burned annually, but fire is less severe than in the derived savanna.

In the 'wooded steppe' (sahel savanna) a water deficit exists for most of the year and many areas receive less than 200mm 0f rainfall. The rain occurs in down pours scattered over a 2-3 month period.

The original climax was probably thorn woodland. This has opened up with scattered dwarfed trees and of 5-10m height. Thorn shrubs of 2-3m height with short conical bases and divided stems are common.

Grasses are short, discontinuous, wiry and tufted. Less serious fires than further south.

The southern Sahara is fringed with a 'sub' desert steppe. In some places dispersed, permanent vegetation prevails, being composed of small shrubby plants and bushes, with acacias, other trees and shrubs. This area receives about 150mm/year and are extremely unreliable.

After rains, annual grasses and herbs appear and soon mature. Altitude modifies the vegetation due to increased humidity and cloudiness, lower temperature and less evaporation.

Relative humidity has a marked effect on the vegetation association in the different regions. The coastal areas have a mean monthly relative humid of 95% at 06.00 may drop to 60% at noon in the driest months. In the north, the moving relative humidity climbs up to 90% during the rainy season. In the dry season it seldom reaches 30% but drops to less than 10% before noon.

A temperature gradient extends from the coastal forest zones to the Sahara. Temperature lines run east and west, as do the vegetational zones. The gradient effects on vegetational associations are less visible than those of the rainfall. A gentle rise in elevation occurs from south to north. This also causes a change in temperature and has some influence on vegetation type.

Soil-plant-animal interrelationship

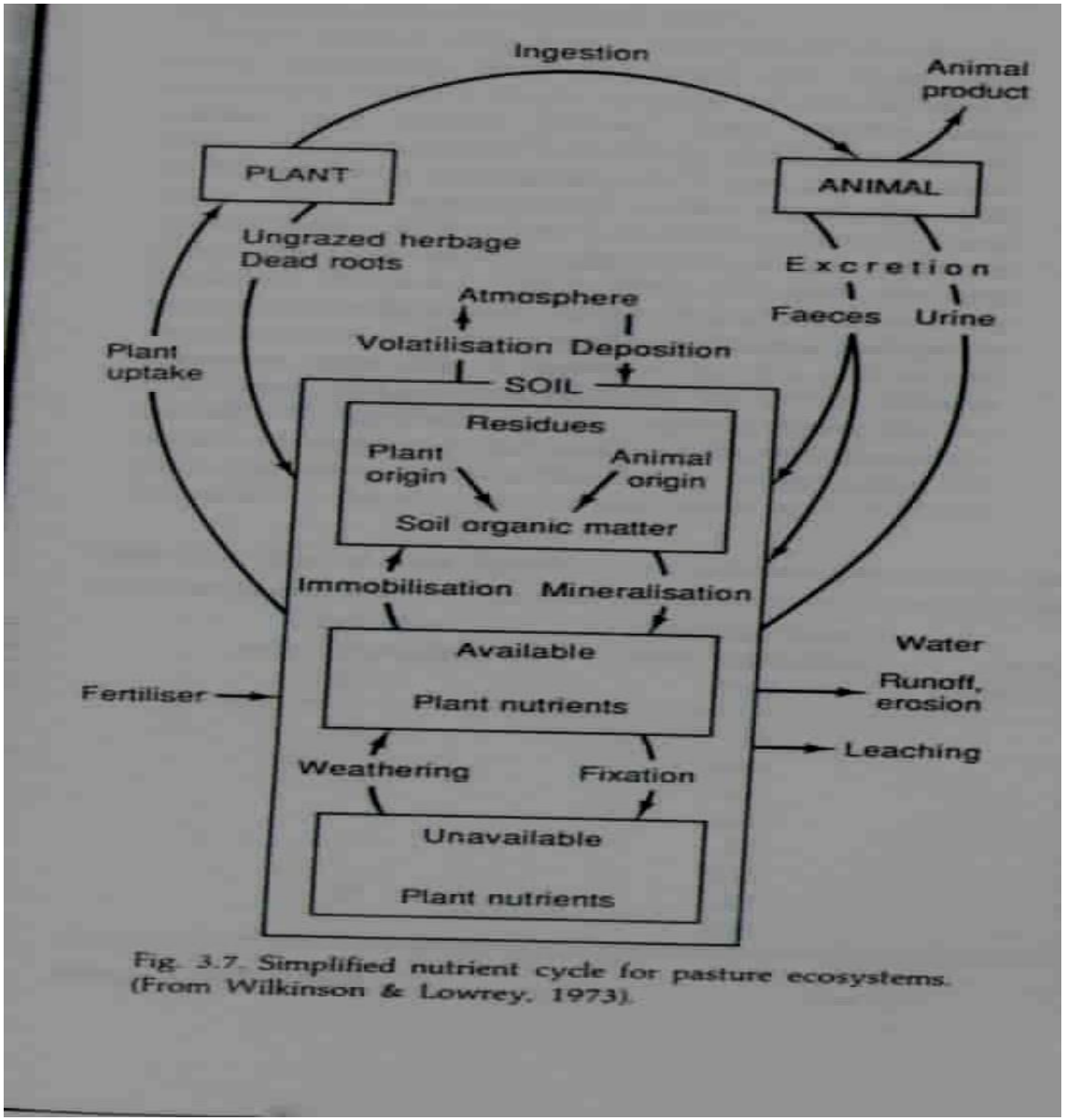
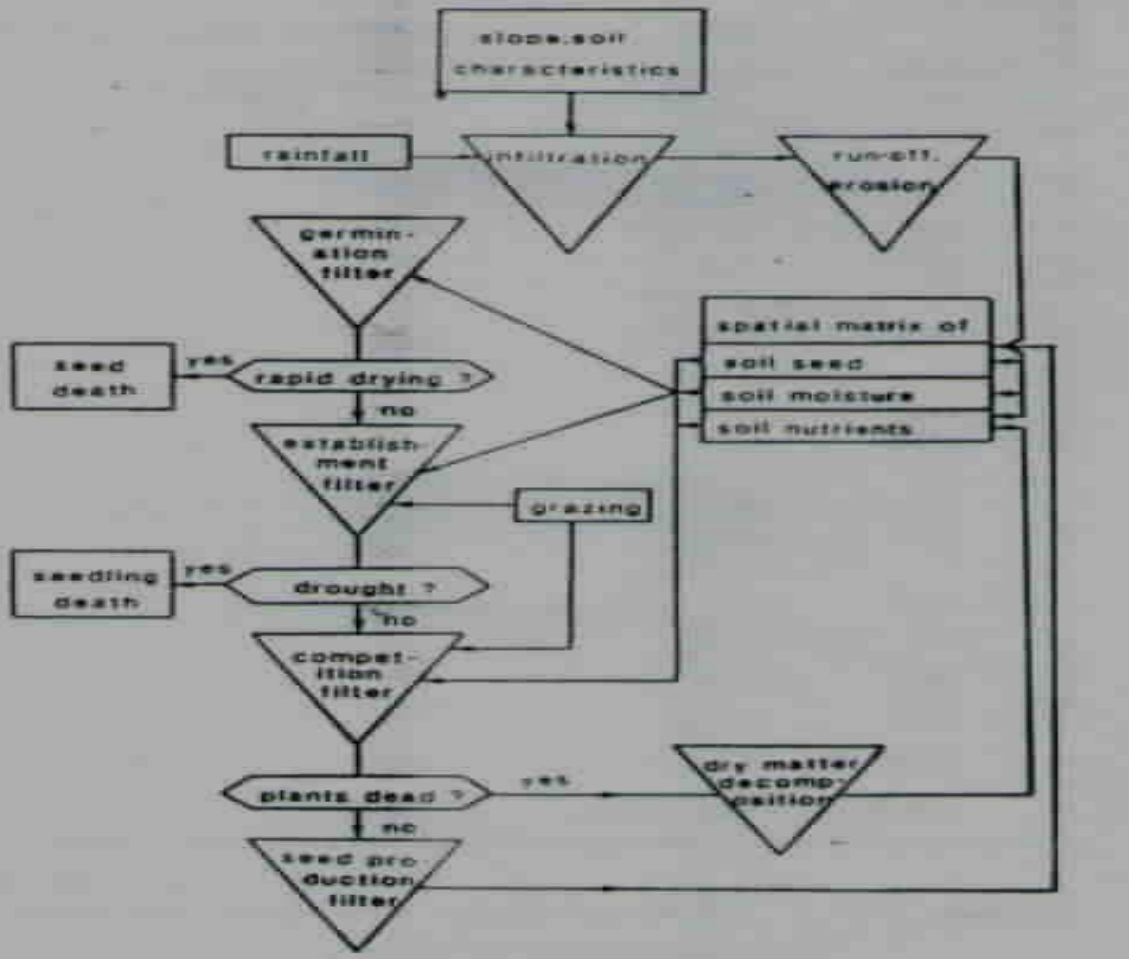


Fig. 3.7. Simplified nutrient cycle for pasture ecosystems. (From Wilkinson & Lowrey, 1973).

Fig. 1.3. Environmental and plant factors that dominate grassland pattern and species cycling in a grassland comprised of Townsville stylo and annual grasses in the wet-and-dry tropics. The factors exert quantitative effects on yield and species composition; the plant factors germination, establishment, competition and seed production may be seen as a series of filters through which individual plants attempt to pass. (From Torssell, 1973.)



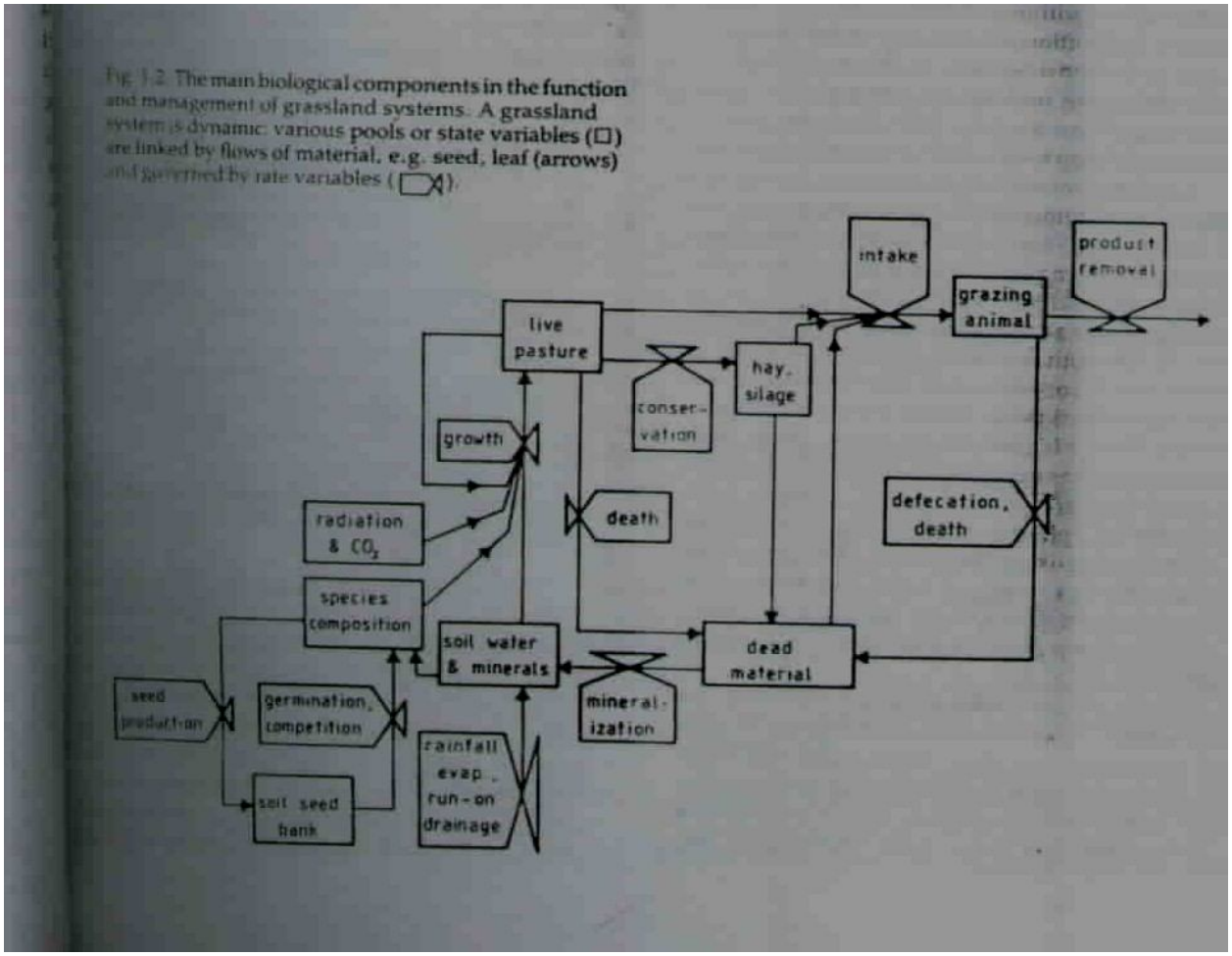


Fig. 1.2. The main biological components in the function and management of grassland systems. A grassland system is dynamic: various pools or state variables (□) are linked by flows of material, e.g. seed, leaf (arrows) and governed by rate variables ( ).

Herbage quality

The suitability of a particular pasture plants depends on the production objectives, considering the environment for pasture establishments, the aims of pasture (e. g the type of animal production, the importance of pasture-crop integration or the necessity for watershed stability) will decide the importance of various pasture qualities (e. g nutritive value, ease of eradication, or ground cover.) Pasture qualities are usually judged in terms of their nutritive value, ease of establishment, and persistence. The value of a pasture must be determined by the output of animal products.

Nutritive value: Is the chemical composition, digestibility and the content of proteins, minerals and vitamins, and the absence of toxins. Nutritive value is being affected by acceptability, presence of undesirables substances, rate of passage and availabilities of forage because they influence the amount of forage consumed.

Chemical composition: This indicates the constituents in the forage and attempt had been made by early nutritionist to determine the chemical composition of a given feed stuff.

The weende's proximate analytical scheme resolves a given feed stuff into five fractions namely: Crude protein (CP) through determination of kjeldhal nitrogen and multiplying N value by 6.25; fat or ether extract (EE) through extraction with anhydrous ether; Crude fibre (CF) determined by extractions with ether, sulphuric acid and sodium hydroxide; ash content using muffle furnace and nitrogen-free extract (NFE) determined by subtraction of CP, EE, CF and ash contents from sample weight.

Classification of forage fractions according to nutritive characteristics (from Van Soest, 1966 and 1967)

		Nutritional availability	
Class	**Fraction**	**Ruminant**	**Non-ruminant**
Category A			
(Cellular contents)	**Sugars, soluble carbohydrates,**		
	Starch	**Complete**	**Complete**

	Pectin	**Complete**	**High**
	Non-protein N	**High**	**High**
	Protein	**High**	**High**
	Lipids	**High**	**High**
	Other soluble	**High**	**High**
Category B			
(Cell wall contents)	**Hemicellulose**	**Partial**	**Low**
	Cellulose	**Partial**	**Low**
	Heat-damaged		
	Protein	**Indigestible**	**Indigestible**
	Lignin	**Indigestible**	**Indigestible**
	Keratin	**Indigestible**	**Indigestible**
	Silica	**Indigestible**	**Indigestible**

The above is with the belief that CF is totally indigestible while NFE is totally digestible but this is not true. Crampton and Maynard (1938) resolved carbohydrate into lignin, cellulose and other carbohydrates to predict the feeding value. Van Soest (1966) proposed that forages are made up of two basic dietary fractions namely: Cell content (CC) and cell wall content (CWC).

Fig. 2.2: Various systems of partitioning the dry matter of forage (Harris, 1970) taken from Crowder and Chedda, 1982)

<table>
<tr><td colspan="5">DRY MATTER</td></tr>
<tr><td colspan="4">ORGANIC MATTER</td><td>ASH</td></tr>
<tr><td>CRUDE FIBRE</td><td colspan="2">NITROGEN FREE EXTRACT</td><td>ETHER EXTRACT</td><td>CRUDE PROTEIN</td><td>ASH</td></tr>
<tr><td colspan="2">CELL WALLS
(NEUTRAL DETERGENT FIBRE)</td><td colspan="3">CELL CONTENTS (NEUTRAL DETERGENT SOLUBLES)</td></tr>
<tr><td colspan="2">CELL WALLS
(FONNESBECK & HARRIS)</td><td colspan="3">CELL CONTENTS</td></tr>
<tr><td>NON-NUTRITIVE MATTER</td><td colspan="2">PARTIALLY NUTRITIVE MATTER</td><td colspan="3">NUTRITIVE MATTER</td></tr>
<tr><td>LIGNIN & ACID INSOLUBLE ASH</td><td>CELLULOSE</td><td>HEMICELLULOSE</td><td colspan="3">SOLUBLE CARBOHYDRATE, PROTEIN,
ETHER EXTRACT, SOLUBLE ASH</td></tr>
</table>

ORGANIC MATTER SYSTEM

WEENDE'S OR PROXIMATE SYSTEM

VAN SOEST SYSTEM

Factors affecting chemical composition

1. Soil and climatic factors

2. Stage of growth

3. Genotype:

4. Sampling and processing

5. Toxic substances: Some forages that rated high in their dietary components also contain substances such as cyanogenetic glucosides, organic acids such as oxalic acid, amino acids, alkaloids, oestrogenic isoflavones and saponin which cause deleterious effects in livestock that feeds on them.

Digestibility is an important measure of the nutritive of forage and can be defined as the difference in value between the feeds eaten and materials voided by the animals, expressed in percentage of feed eaten. Thus, the overall digestibility of forage will be the summation of the content, digestibility of the chemical components of the forage (Harden 1975)

Factors affecting digestibility

1. Stage of growth and genotype – Digestibility declines with advancing age and (maturity) rate vary considerably between genera, species and varieties.

a. Plants high initial digestibility (70-85%) followed by high decline – Andropogon gayanus, cynodon dactylon, Pennisetum purpureum, sorghum sudaness.

Intermediate initial digestibility (60-70%) followed varying decline – Andropogon gayanus, Cynodon dactylon, Dactylis glomerata & Digitaria unighumos.

Low initial digestibility (50-60%) generally Low rate of decline – Paspalum, Cymbopogon, Hyparrhenia and Themeda spp.

2. Plant fractions

3. Climate

4. Protein and mineral content

5. Digested products: Quantitative determinations of these acids and their relative proportions, as well as the efficiency of their utilization by the animals are also used to estimate the nutrient value of forages.

Forage Intake: The feeding value of a feed is related to the amount which the animal will consume voluntarily. Assessment of forage quality depends not only on the nutritive value of the forages, but also on the total quantity of digestible nutrients consumed by the animal. In Ruminates, unlike monogastrics intake depends on the capacity of the digestive system, particularly the rumen.

Factors affecting intake

1. Season of the year

2. Stage of growth

3. Digestibility & genotype

4. The animal factor – size of animal, potential productions

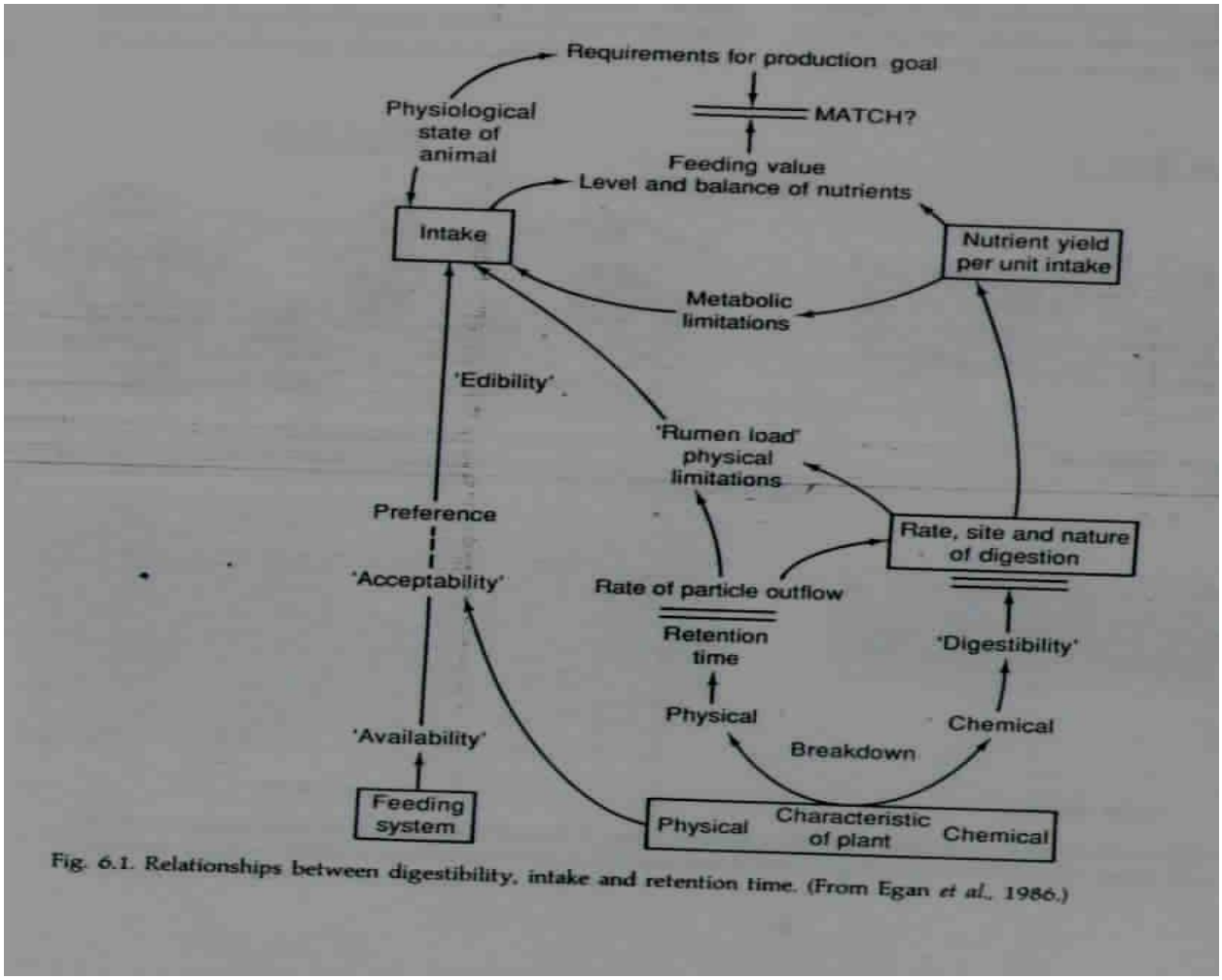


Fig. 6.1. Relationships between digestibility, intake and retention time. (From Egan *et al.*, 1986.)

Pasture Terminologies

Acceptability: Readiness with which animals select and ingest a forage; sometimes used interchangeable to mean either palatability or voluntary intake.

Ad libitum: the voluntary intake achieved when feed is available to the animal at all times.

Acid detergent fiber (ADF): Insoluble residue following extraction with acid detergent (Van Soest); cell wall constituents minus hemicellulose.

Acid detergent lignin (ADL): Lignin in the residue determined following extraction with acid detergent.

Adventitious roots: The second root system which develops from the lower nodes of each grass tiller.

Browse: A class of range forage including twigs with their shoots and leaves which are selectively cropped by livestock or other wild herbivores from shrubs, small trees and woody vines.

Carbohydrate: Complex polyhydroxy, aliphatic aldehydes and their anhydric polymers which the proportion of hydrogen and oxygen generally are the same as in water e.g. glucose, sucrose, starch, cellulose

Climax: A fully-developed plant community, with the plant cover and its environment in equilibrium.

Fodder: Coarse grasses such as corn and sorghum harvested with the seed and leaves and cured for animal feeding.

Grassland: Any plant community in which grasses and/or legumes comprise the dominant vegetation

Grazing capacity: number of animals a given pasture will support for a given period of time.

Hemicellulose: A group of complex carbohydrates somewhat less resistant to digestion than cellulose.

Herbaceous: plant growth that is relatively free of woody tissue

In vitro: in glass; in test tube; out side the organism; as digestion in vitro

In vivo: in a living organism, such as an animal or plant

Lignin A complex strengthening material in the thickened cell wall of plants; much less digestible than cellulose.

Digestible nutrients That portion of the nutrients consumed which are digested and taken into the animal body. The term is generally applied to the proteins, carbohydrates and fats.

Ecotype - A plant type within a variety or strain that has resulted from exposure to a particular environment.

Species - Species consists of a natural population of plants with common morphological characteristics (phenotypically similar), having a common ancestry and capable of replacing like types (Lawrence 1951). It is identified taxonomical by the secondary name of the binominal used as a scientific name. this group is the most important botanical unit for the pasture agronomist and cattleman, since plants of species may have broad adaptability to diverse soil and climatic conditions.

Concentrates – Feeds that are low in fibre and high in total digestible nutrients. Technically, all feeds supplying primary nutrients (protein, carbohydrate and fat) are classed as concentrates if their crude fiber content is less than 18 per cent. Egs are grains, copra meal and rice bran.

Cultivars - 'Cultivars' is the internationally recognizable term for the agricultural variety . A cultivar is a cultivated population of plants with recognized, morphological, physiological, chemical or other differences. They may follow generic, specific or common names e.*g* *Desmodium* Greenleaf. *Desmodium intortum* Greenleaf or *desmodium Greenleaf*.

Varieties: - 'varieties' are morphological variants and subdivisions of the species. In botanical literature, they will be written with the specific name e.g *Panicum maximum var. Ntchisi, Imperata cylindrical* var. africana to distinguish it from those of other area.It can refer to plant population of the same species which differs from another one in one or more recognizable inherited characteristics.

Grazing capacity: – number of animals a given pasture will support for a given period of time

Apomixis: Term applied to reproduction if viable embryos are formed without actual union of male and female gametes, as in Guinea corn.