**Forage crops**

**Forage:** Vegetative plant parts (i.e leaves, flowers and stems of plants) eaten by animals, could be domesticated or wild animals.

**Fodder:** More specific term referring to the vegetative part of cultivated forages or crops used as forages**.**

**Feed:** Is a more general term that includes also non-vegetative plant parts e.g grains, seed etc. fed to animals. Sometimes, it is difficult to differentiate between feed, forage and fodder, for example when animals consume the seed head and other part of herbaceous plants together.

**Roughages:** Rough forages which contain a high ratio of fiber, while the ratio of protein and vitamins may be Low.

**Concentrated**: Forages which containing a low percentage of fiber, while the ratio of protein and vitamins are high.

**Straw:** A product of forage crops, which is a dry parts of crop remnants after taking seeds.

**Hay:** it is harvested forage at a specific growth stage and dried to moisture percentage 15-20%.

**Silage:** storage in isolation from the air and transformed sugars to lactic acid and reduced PH from (6-7) to 4, stop action of bacteria and remains conservative on the nutritional value.

**Soiling:** refer to vegetative nutrition, cut vegetative forage is green and submit to the animals in the pasture.

**Grazing:** refer to feeding animals in the field without cutting**.**

**Forages crops are classified into two basic broad groups:**

(i) Herbaceous plants

(ii) Woody plants.

While woody plants grow cumulative over many years, herbaceous species show an annual cycle of growth and decay, re-growing each year from seed, but perennial herbaceous species regrow from existing root stock.

Among the herbaceous group, two subgroups are most particular interest as sources of forage, such as:

1. **Grasses:** These make up the bulk of plants found in many mixtures of the natural vegetation that supply animal feed. Grasses also have certain characteristics that make them very suitable as herbage plants.
2. **Legumes:** these have a relatively high value for animal production, mainly on account of the high nitrogen content in the vegetative matter that represent the animal feed. They also play significant roles components in sustainable agricultural systems.

**Forage Sources**

 **Rough Concentrated**

**Vegetative Dry**

**1. Natural grazing 1. Straw 1.The bran 2. Fodder 2. Hay 2. Rice remnants 3. Grazing in cultivated areas 3. Silage 3. Grains ….. 4. Residues of sugar … Factories**

**A brief history of the cultivation of forage:**

There are no facts or documents indicate to the beginning of agriculture, but there are pointers to the history of domestication (transfer organisms from wilderness state to state pet) to be modern comparison on cereal cultivation **,** reason for this is that Neanderthal adopted on hunting in the beginning of his life and when breeding animals adopted on natural grazing.

Agriculture is a turning point in human history where transformed it from travel, migration and search for food depending on hunting to a life of stability. First plants planted by humans and was the most capable of production are grassy crops such as wheat.

When started, population growth and increase animals number in addition to some areas suffering from extreme cold and drought in some seasons as a starting point, the idea of ​​growing crops as forage and alfalfa is the first forge crop knew at that time.

Greeks are the first to have proficient in this field and agriculture date back to 2500 BC It is believed that alfalfa and clover. The cultivation dates of Egyptian clover return to the Greek and Roman. After that developed forage crops, and then moved to Europe and then to America, the first global conference in 1927 and was held in Germany.

**Economic and agricultural importance of forage crops:**

1. Lower price.
2. High nutritional value.
3. Interference in agricultural rotations.

**Importance of forage crops:**

1. **Economic Importance:**

This importance comes from the following factors:

1. The presence of animals in the region or country and therefore the need to provision of forage for perpetuating and developing.
2. Provide forage plants by virtue of the nature of the land and environmental conditions.
3. Commerce and achieve a profit.
4. Needs of human to animal protein.
5. **The importance and benefits of forage in agricultural side:**
6. **Soil conservation.**
7. **Crops rotation.**

Forages can be the simple answer to soil erosion and decline in organic matter and fertility, a problem caused by modern cultivation. Forages can also help reduce nitrogen fertilizer costs and the energy costs associated with applying nutrients.

Many farmers are using forages for positive results on any land. The benefits in include:

1. **Increased Soil Fertility :** Legume forages such as alfalfa are usually inoculated with rhizobia bacteria at the time of seeding in order to force the development of tiny nodules on the plant root hairs. These nodules capture nitrogen (N) from the atmosphere and make it available for plant growth and development, a process called nitrogen fixation. Because inoculated legumes are very effective at nitrogen fixation, they are able to return their stored nitrogen to the soil through root decay for subsequent grain crops to utilize.

When a legume grass stand is terminated, there will be high amounts of nitrogen for subsequent crops at the beginning of the following season, but it will be lost if it is not used. On the other hand, studies show that in a no-till system when herbicide is used for crop termination, N becomes mineralized and is released more slowly at rates that can be better utilized by plants. This type of N release is metered out over the growing season and into the next, and can improve protein levels in spring wheat.

1. **More Organic Matter:** The extensive root systems of perennial forages add significant amounts of soil organic matter. A 3-year perennial forage crop has been shown to return more than twice the soil organic matter as annual crops such as cereals or pulse crops. Soil organic matter is the energy which fuels decomposer organisms, which in turn affect soil structure, water-holding capacity, and resistance to both compaction and erosion.
2. **Less Crusting:** Soils higher in organic matter have fewer tendencies to crust, a problem when you are establishing many small-seeded crops and large-seeded pulses.
3. **Better Water Infiltration and Drainage Forage:** Roots improve water infiltration, especially on clay soils. This results in improved soil drainage and water use by subsequent crops, and it can help producers get on the land earlier in spring when excess moisture is often an issue. Improved drainage is especially evident when alfalfa is terminated with herbicide, rather than tillage, because soil pores and tunnels remain intact.
4. **Subsoil Advantages:** Studies have shown that a perennial legumes drainage effect on subsoil lasts for at least 2 years after stand termination, particularly with alfalfa. On clay soil, because of this improved drainage, alfalfa-based rotations produce higher wheat yields than those of annual grain-based rotations.
5. **Less Tillage in Subsequent Crops:** Because of increased organic matter and better internal drainage, soil becomes more workable and requires less tillage.
6. **Less Root Disease:** Studies on cereal crops following 3-year forage hay stands have shown that there are reduced occurrences of common root rot. Perennial forage crops break disease cycles by removing host plants from the rotation for a longer term, thus reducing the level of pathogens in the soil.
7. **Reduced Salinity:**

Soil salinity is caused when high water tables bring salts to the soil surface. Through deep roots that improve drainage, forages help to lower the water table level and thus reduce soil salinity. Alfalfas extremely deep roots can also lower salinity levels in the rooting zone of subsequent crops.

1. **Less Erosion:**

Crop rotations that include forages provide more soil cover. Soil has higher levels of organic matter and a more stable structure to reduce the potential for wind and water erosion.

1. **Anti-Leaching Effects:** Perennial legume forages can extract nutrients such as N and phosphorus (P) from up to a 10-foot depth due to their deeper and more permanent root system as compared to annual crops. In particular, the deep taproot of alfalfa can utilize nitrogen that has leached past the rooting zone of annual crops  up to a depth of 3 feet the first year to 9 feet in year 4, according to recent research based on a four-year alfalfa stand.
2. **Increased Yield and Quality in Following Grain Crops:** Forages can produce increased yields in your subsequent grain crops, and improve quality, too.

**How to choose the appropriate vegetative fodder?**

When choosing the appropriate fodder should take into consideration the following points**:**

1. **High production capability:** Can be obtained at the highest productivity through appropriate fertilization, weed control, resistance to pests and diseases, appropriate irrigation and the use of high production varieties**.**
2. **Distribution of production throughout the year:** Facing the process of the production of green fodder problem of availability throughout the year where compete economic crops for human nutrition.
3. **Compatibility species:** Must consider the compatibility of species, especially when planting forage mixtures.
4. **Easily create pasture:** taking into account the ways of cultivation.
5. **Crop's ability to produce seeds:** It is important to get the proper amounts of seeds to re-agriculture.
6. **The ability to bear environmental conditions:** Choose crops suitable to the conditions prevalent in the region.
7. **Length of survival:** As divided crops to annual, biennial and perennial plants and so you must choose the appropriate type to period of stay required.
8. **Forage crops do not contain the toxic compounds:** Sometimes accumulates toxic substances such as prussic acid and nitrate salts, especially in abnormal environmental conditions as in sugar crops such as corn and Johnson grass is a natural.

**Forage Establishment**

The way for production of success full fodder begins with field has good plants and can't get it, only by achieving the following requirements:

1. The use of good and vitality seeds and suitable varieties to the conditions of the region.
2. Prepare the appropriate seedbed.
3. Planting seeds at a suitable depth.
4. Weed control.

**Good seeds qualities:**

1. High germination rate.
2. Purity of seeds from the weeds seed, pests and diseases.
3. Large seed size and increased qualitative weight.

**Seed bed preparation:**

A quality of seedbed is the most important feature in obtaining maximum germination of forage seeds. The ideal seedbed features:

1. Surface level enough that machinery can place seed at a satisfactory depth;
2. Enough fine soil aggregates to put the germinating seed in close contact with soil and allow moisture to transfer to the seed;
3. Soil surface rough enough to prevent crusting on the surface.

**Methods of seeding:**

1. Broadcasts the seed.

Advantages:

1. Reduces weeds competition.
2. Reduces seedling death as a result of cracked soil.
3. Increased utilization of fertilizer distributor.

Disadvantages:

1. Difficulty distributing small amount of seeds regularly.
2. Failure to ensure cover seeds.
3. Cultivated as drill rows.

Advantages:

1. Control the amount of seed.
2. Ease of weed control.
3. Possibility of the use of mechanical harvesters.
4. Concentration of fertilizer near the lines specially when using band seeding.

**Seeding depth:**

Seeding depth depends on the size and specific weight of seeds and is also affected by the availability of moisture**.**

**Quantity of seeds (seeds amount):**

That is depending on some factors such as:

1. Availability of moisture.
2. Plant type.
3. Forage type.
4. Seedbed.
5. Soil fertility.

**Seeding date:**

Depends on the type of crop and appropriate season. Generally early planting is better than late as it is the longer growing season increased yield.

**Forage harvest:**

The harvest is to leave the animals for grazing or use of mechanical machines and stored according to the type of forage.

**Legume forage crops**

**Alfalfa (*Medicago sativa* L.)**

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| --- |
| [**Scientific classification**](http://en.wikipedia.org/wiki/Biological_classification) |
| Kingdom: | [Plantae](http://en.wikipedia.org/wiki/Plant) |
| Division: | [Angiosperms](http://en.wikipedia.org/wiki/Angiosperms) - Magnoliophyta – Flowering plants |
| Class: | [Eudicots](http://en.wikipedia.org/wiki/Eudicots)- Magnoliopsida – Dicotyledons |
| Clade: | [Rosids](http://en.wikipedia.org/wiki/Rosids) |
| Order: | [Fabales](http://en.wikipedia.org/wiki/Fabales) |
| Family: | [Fabaceae](http://en.wikipedia.org/wiki/Fabaceae) |
| Genus: | [Medicago](http://en.wikipedia.org/wiki/Medicago) |
| Species: | M. sativa |

Alfalfa is a [perennial](http://en.wikipedia.org/wiki/Perennial) forage [legume](http://en.wikipedia.org/wiki/Legume) which normally lives 4–8 years, but can live more than twenty years. Also called [lucerne](http://dictionary.reference.com/browse/lucerne), purple medic. Was one of the first forage crops that domesticated. It is used as multi-purpose forage, able to be used for both grazing and conservation (hay, silage, meal and forage dehydration). It can be sown as a pure stand or in mixtures with both temperate and tropical grasses. The seed can also be used for human consumption as sprouts.

**History:**

One of the oldest forage crops used in agriculture at the time of pre-history. Originated in the Middle East, came from West Asia (Iraq , Iran and Pakistan) then moved to the Greek civilization and Romanian then reached North Africa and Europe.

**Economic importance:**

It was important economic crops called the queen of forage crops. planting widely in the world and this distribution reasons for:

1. Produce high amounts of forage.
2. Have high nutritional value.
3. High protein content may reach (20 - 25%).
4. Adapt to varying environmental conditions.

**Nutritional value:**

Alfalfa is high in [protein](http://en.wikipedia.org/wiki/Protein), [calcium](http://en.wikipedia.org/wiki/Calcium), plus other minerals, [vitamins B group](http://en.wikipedia.org/wiki/Vitamin_B), [vitamin C](http://en.wikipedia.org/wiki/Vitamin_C), [vitamin D](http://en.wikipedia.org/wiki/Vitamin_D), [vitamin E](http://en.wikipedia.org/wiki/Vitamin_E), and [vitamin K](http://en.wikipedia.org/wiki/Vitamin_K). The sun-dried hay of alfalfa (also known as Lucerne) has been found to be a source of vitamin D.

Protein content ranges between 20-25% are concentrated in the leaves and prefer to drying plants at the stage of formation of buds where high-rate leaves. Protein decrease with the progress of plant age because the ratio of leaves to stem will be decreased.

**Species, Groups and Cultivars:**

* **Division by species**

Alfalfa grown globally followed two types:

1. ***Medicago sativa***: This type is characterized by purple flowers. It is the most common type.
2. ***Medicago falcata***: This type is less common and is characterized by yellow flowers.
* **Division according to the color of flowers**

Scientists have suggested the division of existing varieties globally to some groups depending on several points, such as the color of flowers, the origin and resistance to cold and disease. Divided into the following groups:

1. **Common alfalfa:** characterized purple flowers, Asian origin, limited resistance to cold, sensitive to bacterial wilt disease. Includes varieties widespread in the United States, Australia and South Mediterranean countries.
2. **Turkestan alfalfa:** characterized purple flowers, short plants, slow growth after mowing, high resistance to cold and drought and resistance to bacterial wilt disease. Origin of these varieties Turkistan region.
3. **Variegated alfalfa:** This group resulted from crosses between purple and yellow flowers, so be color purple flowers with yellow or brown spots. These varieties are more resistant to cold, but it is sensitive to bacterial wilt disease.
4. **Peruvian alfalfa:** Plants List, a few branching, large leaflet, do not bear the cold, short-period its survival compared to other groups.
5. **Arabian alfalfa:** Stake root and few branching, list and hollow stem, large and pale leaflet and flowers, a fast-growing and not resistant to cold.
6. **Hybrid alfalfa.**
* **Division according to the cold resistant**
1. **Hardy alfalfa**
2. **Medium hardy**
3. **Not hardy alfalfa**

**Sowing time:**

From February to June, depending on the climatic region. The later months are applicable to the winter rainfall regions. Seed must be inoculated with the correct Rhizobium bacterium before planting.

**Sowing rate:**

Dryland: 5 kg / ha in 900 mm rows, where mean annual rainfall is< 500 mm.

10 - 15 kg / ha in 250 mm rows or broadcast in areas where mean annual rainfall > 500 mm is.

Irrigation area: 25 kg / ha broadcast.

**Appropriate climate:**

Grow in a wide range of climatic conditions as they bear the heat and extreme cold. Optimal growth temperature between 15-30oC. Because it is perennial plant could bear unstable environmental conditions.

**Soils for Growing Alfalfa:**

The ideal alfalfa soil is deep and well drained. Alfalfa has a vigorous root system which enables it to obtain water and nutrients from a large volume of soil. This characteristic helps alfalfa produce high yields and live through dry periods. Poor soil drainage restricts oxygen supply to the roots, increases winter heaving problems, causes more disease problems, and damages alfalfa’s nitrogen-fixing bacteria. These effects all lead to low productivity or loss of the stand. Less than ideal soils can be used for growing alfalfa.

**Alfalfa pasture types:**

Some alfalfa varieties valid mainly for grazing and planting mixtures with some grasses. These varieties plants characterized by the following:

1. Have the potential to Spanning and spreading. Spanning would be through:
2. Short rhizomes arises from the crown area such as Rhizoma, Severla and Teton.
3. Spreads by creeping roots grow from the root. These varieties known with creeping rooted alfalfa such as Rambler and Travois.
4. Deep-set crown (lower the crown area below the soil surface).
5. Slow growth after grazing.
6. Drought-tolerant and cold due to the large root.

**Disadvantage of previous varieties:**

1. Lack of forage production.
2. Weak resistance to disease and insects.
3. Strongly influenced by environmental conditions.

**Prepare the ground for planting:**

Attention must be taken operations of service and prepare the ground well, because it is a perennial crop any error leads to problems in irrigation, mowing, limited of yield and reduces the life of the field. Seed bed must be medium roughness and free from blocs.

**Methods of cultivation:**

1. **Seeding in water:** Undesirable because of the waste of water resources and lack of quality germination but prefers in saline soils.
2. **Broadcasting:** Disperse seeds on the soil surface and covered with a light layer of soil. Maligned this way limited the distribution of seeds and erratic depth.
3. **Drilling:** Preferred to the depth of farming 1.5cm and the distance between the lines 15cm.

**Fertilization:**

Provides nodes bacterial fill the need of nitrogen. Generally the important elements are phosphorus and potassium. Phosphate fertilizer can be added up to 20-25 kg fifth phosphorus oxide per dunam. As for the animal fertilizer have dual impact. Help to improve the properties of the soil and add some nutrients, such as phosphorus, potassium and some rare elements, but they cause the transfer of weed seeds. Applications of boron have proved beneficial. In some areas, boron means the difference between success and failure.

**Alfalfa in rotation:**

Alfalfa has long been recognized as a legume of great value as a soil improving crop. It is used extensively in irrigated regions not only for its own value, but for its beneficial effect on succeeding crops. Alfalfa may deplete subsoil moisture in the root zone. Crop management should take this into the account. In drier areas, a crop such as sorghum often follows alfalfa. Wheat, oats and flax are used to some extent. In regions of abundant rainfall, corn is a good crop.

**Cutting alfalfa:**

When cutting alfalfa must take into account the following matters:

1. Ensure the survival of plants in the vital enough enable it to restore growth after cutting and thus continue production year after year.
2. Insurance to obtain the largest possible amount of digested food in the forage. It is known that protein and carotene content became less, fiber ratio increase and decreased palatability with advancement of plant age. If you cut a small plants gives a good forage, a small amount and detrimental to the vitality of the plant therefore must be reconciled between these two points.

**Studies have indicated to the following:**

1. Alfalfa does not start storing food in the roots and crown area, except when the plant height reaches to 20-25cm and food storage reaches the maximum with high proportion of flowering.
2. Cut alfalfa when the flowering rate reaches to 25%. This time is considered compatible with the plant vitality, the amount and quality of forage.

 **Mowers are based on:**

1. A fixed period of time: Common way and facilitates the organization of the service. Can hold 8-10 mowers during the year.
2. Growth stage:
3. Basal buds

**Cultivation of alfalfa for seed production:**

In the case of planting for seed production you must be used less seed rate and increase distances between the lines. Preferably take the yield in second or third year because the first year plants are weak and should be reduced mowers.

**Weed control:**

Unless controlled, weeds such as crabgrass, foxtail, fallpanicum, and chickweed can drastically reduce alfalfa stands. Alfalfa is especially susceptible to weed pressure during establishment. Fortunately, herbicides are available that do a good job of controlling the annual grasses and some broadleaf weeds such as carbine, dalapon, EPTC, traflan and 2,4-DB.

If pre-emergence herbicides are used to control annual grassy weeds when planting alfalfa, you cannot plant forage grasses with the alfalfa. If mixed stands are desired, the grass should be drilled into the established alfalfa in late summer.

**Diseases and Insects:**

1. Common leaf spot: caused by *Pseudopeziza medicaginis*appeare brown spots on leaves.
2. Dodder (*Cuscuta spp*.)
3. Leaf worm (army worm)
4. Beet army worm
5. Alfalfa Weevil
6. Red spider
7. Grasshoppers

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| Clade: | [Rosids](http://en.wikipedia.org/wiki/Rosids) |
| Order: | [Fabales](http://en.wikipedia.org/wiki/Fabales) |
| Family: | [Fabaceae](http://en.wikipedia.org/wiki/Fabaceae) |
| Genus: | Trifolium |
| Species: | *T. alexandrinum* |
| **Binomial name** | *Trifolium alexandrinum L.* |

**Egyptian clover (*Trifolium alexandrinum*)**

**Egyptian clover:** Is an annual [clover](http://en.wikipedia.org/wiki/Clover) cultivated mostly in irrigated sub-tropical regions, and used as fodder, mainly for cattle and milk buffalo. It was an important winter crop in ancient Egypt, and was introduced into northern India in the early nineteenth century. It is also grown in the United States and Europe.

**Economic importance:**

1. Important forage crops because it gives a large number of mowing (5 -7) and a large quantity.
2. Can be fed to animals in several ways of green fodder, silage or hay.
3. Can benefit from straws output after separating seeds for feeding animals, especially sheep.
4. Characterized by high degree of palatable for animals.
5. Keeps soil fertility where it adds to the soil of 10 -15 kg nitrogen / donum.
6. Helps to improve soil properties because it increases the organic matter and used as fertilizer green better than other legumes for speed decompose and turn to a valid material for plant food.
7. Resistant to salinity and it is one of the crops that cultivated for reclamation saline and alkaline lands.
8. Possess high nutritional value and is an integrated food for the animals because it contains a high percentage of crude protein, calcium, phosphorus, and vitamins.
9. Cultivated as a temporary or catch crop and mowing once or more.

**Types and varieties:**

1. **Single-cut types:** In this type does not grow basal shoots in the crown area, but branched out from the upper half. Such as stallion clover which used as a catch crop before the summer crops such as Fahl.
2. **Multi-cut types:** This type is characterized by basal branching which active in lower leaves and given new branches during different periods of growth

Examples of these types:

1. Al-khdharaoy clover gives 4-7 stuffed during the season.
2. Al-mescawi clover gives 3-5 stuffed during the growing season.
3. Al-saidi clover and gives 2-3 stuffed during the growing season.

**Sowing date:** From October to November.

**Seed rate:** 6-8 kg / donum differs depending on varieties and cultivated method.

**Methods of cultivation:**

1. **Sowing in water:** Prepare the ground with good plowing, smoothing and settlement. Even saturated with water and keep surface of a thin layer of glistening (2-3 mm) thick water is then broadcasting seeds.
2. **Dried sowing:** Used in sandy soils where the ground is prepared well
then divided into blocks and then broadcasting seeds and cover or Drilling**.**

**Soil:**

It will grow on a wide range of soils, preferring heavy loams, provided that they are not waterlogged. It is tolerant of relatively high salt concentrations but not nearly as hardy.

**Fertilization:**Often not add nitrogen fertilizer for plants' ability to atmospheric nitrogen fixation, but added only in the weak and new lands and at the delay in sowing. Usually clover fertilization rate of 25 - 50 kg Super Phosphate / donum before planting.

**Irrigation:**First irrigation add after 5 - 10 days from agriculture depending on land type and air condition so as not to crack the ground and suffered roots to the sun and causes die a large seedling. The total number of irrigations ranging between (8-10).

**Mowers in the Egyptian clover:**

Depends on the varieties. Fahl gives one cut after 90 days from sowing. Al-mescawi gives 4-5 the first cutting after 70 days in the meddles and southern areas either in the northern regions after the 140-150 and the second cutting after 40-45 days. Third cutting after 35 days. The yield in the first and second mows higher than latter.

**Seed Production:**

1. Take into account the number of cutting when the target is seed production.
2. Interest in the irrigation process. Interrupt irrigation after flowering.
3. Must provide insect pollinators especially honeybees, which pollinated about 90% of plants because there is the self-repulsion phenomenon in clover.

**Diseases and Insects:**

1. Cotton leaf worm.
2. Egyptian clover weevil.
3. Clover seed Chalcid.
4. Stem and leaf rust: causes by *Uromycestrifollii*.
5. Dodder (*Cuscuta spp*.).

**Forage quality**

**F**orage quality can be defined as the extent to which a forage has the potential to produce a desired animal response.

Factors that influence forage quality include the following:

* **Palatability** *Will the animals eat the forage?* Animals select on forage over another based on smell, feel, and taste. Palatability may therefore be influenced by texture, leafiness, fertilization, dung or urine patches, moisture content, pest infestation, or compounds that cause a forage to taste sweet, sour, or salty. High-quality forages are generally highly palatable.
* **Intake** *How much will they eat?* Animals must consume adequate quantities of forage to perform well. Typically, the higher the palatability and forage quality, the higher the intake.
* **Digestibility** *How much of the forage will be digested?* Digestibility (the extent to which forage is absorbed as it passes through an animal’s digestive tract) varies greatly. Immature, leafy plant tissues may be 80 to 90% digested, while less than 50% of mature, stem my material is digested.
* **Nutrient content:** *Once digested, will the forage provide an adequate level of nutrients?* Living forage plants usually contain 70 to 90%water.To standardize analyses, forage yield and nutrient content are usually expressed on a dry matter (DM) basis. Forage dry matter can be divided into two main categories: (1) cell contents (the non-structural parts of the plant tissue such as protein, sugar, and starch); and (2) structural components of the cell wall (cellulose, hemicellulose, and lignin).
* **Anti-quality factors:** Various compounds may be present in forage that can lower animal performance, cause sickness, or even result in death. Such compounds include tannins, nitrates, alkaloids, cyanoglycosides, estrogens, and mycotoxins. The presence and/or severity of these elements depend on the plant species present (including weeds), time of year, environmental conditions, and animal sensitivity. High-quality forages must not contain harmful levels of anti-quality components.
* **Animal performance** is the ultimate test of forage quality, especially when forages are fed alone and free choice. Forage quality encompasses “nutritive value” (the potential for supplying nutrients, i.e., digestibility and nutrient content), how much animals will consume, and any anti-quality factors present. Animal performance can be influenced by any of several factors associated with either the plants or the animals (figure 1). Failure to give proper consideration to any of these factors may reduce an animal’s performance level, which in turn reduces potential income.

**Chemical composition of forage**

 Herbages contain a variety of chemical constituents which serve as nutrients for herbivores. Some nutrients are sources while others satisfy specific requirements in the body of the animal. The chemical composition of the dry matter of pasture grass is very variable for instance the crude protein (CP) content may range from as little as 30g/kg (i.e. 3%) in very mature herbages to over 300g/kg (or 30%) in young heavily fertilized grass. The fiber content is inversely related to the crude protein content, and the acid detergent fiber may range from 200 to over 450g/kg (20-45%) in very mature tropical grasses. The moisture content is of particular importance when a crop is being harvested for conservation. It is very high in very young material, always in the range of 750 – 780g/kg (75-78%), and falls as the forage matures to about 650g/kg. Weather condition is a major determinant of moisture content. Associations of soluble carbohydrates, starch, organic acids, cellulose and hemicellulose together with lipids (fats) contribute to the energy content of forages. Proteins, vitamins and minerals provide essential components of animal diet and are required in an appropriate balance if animals are to tannins, or even poisonous constituents which may affect animal performance.

**Proteins**

Protein is often the constituent which most limits the performance on animals on pasture. Crude protein (CP) comprises natural proteins (i.e. part of the plant tissue constituents) as well as non-protein constituents (NPN). CP is estimated by multiplying the nitrogen (N) content of the forage by a factor of 6.25.This provides only a gross estimate which does not distinguish between the protein needs of the micro-flora in the rumen and protein available for absorption in the lower digestive tract, or the quality or origin of the protein.

The protein requirement varies according to species of animals, age, and the physiological functions of the animal (e.g. lactating, young, pregnant etc.). Generally, the minimum protein requirement of ruminants is between 7 and 8 % but high producing animals require levels approaching 13% to 14% and where the protein levels is lower than the minimum requirement, protein needs to be supplemented.

**Minerals**

A comprehensive mineral need of livestock is given in tables presented by National Research Council (1984, 1985).Phosphorus is generally in short supply in most of the tropics for most of the year. Supplementation with P is therefore often recommended throughout the year on many types of pasture. When selective grazing is allowed to fully operate as in a continuous grazing system, P intake is never constrained as animals select the young shoots of plants which contain higher proportion of P than other plant parts. Other important minerals for good performance of livestock are Na, Ca, K, Mg, S, Zn, Co, Cu, Mn, Mo, I, Se. The concentration of the minerals in forages is determined to a large extent by the maturity of the material. Mineral concentration declines with age and is also influenced by soil type, soil nutrient levels and seasonal conditions.

**Structural Constituents (Cell wall or fiber)**

The structural constituents of plant materials include polysaccharides, lignin and some proteins. The constituents can be divided into matrix polysaccharides (including hemicellulose and pectin) and fiber polysaccharides (cellulose, lignin, and proteins).All these components have been termed fiber and may be incompletely or variably digested by the animal. The stems of most forage have larger proportion of polysaccharides and lignin than the leaves. This proportion increases with maturity in both tropical and temperate forage species. Tropical species appear to have greater cellulose content and a higher hemicellulose: cellulose ratio than temperate species.

During digestion, once lignin has been removed, the polysaccharides of the cell wall become more readily digestible. The lignin in plant fiber however resists microbial enzyme attack in the rumen and thus reduces digestibility through its linkage with specific points on the polysaccharide chains and it prevents physical attachment of rumen bacteria to plant cell walls.

**Vitamins**

These are another group of essential chemical constituents, but are required only in small amounts. The most important of them is vitamin A which is usually well provided for in green forages and well cured leafy hay.

**Anti-quality and toxic substances**

The final groups of chemicals that are found in forages are toxic substances. Certain legumes (e.g. Lucerne and clover) contain substances which cause bloats. Others contain tannins which reduce the digestibility if forage.

**Palatability and Acceptability**

Palatability is broadly defined as the delight with which a particular specie or plant part is consumed by the animal. It can also be explained as those factors of the feed itself which determine the absolute attractiveness of the feed to the animal. Acceptability on the other hand can be defined as the attractiveness of the feed to the animal as determined by the factors of the forage and the environment. It is therefore a relative term and depends on the circumstance under which the forage is presented to the animal. The distinction between these two terms is not always clear, but the following example will be used to explain it:

A mature grass in the dry season may be both unpalatable and unacceptable but if urea lick is provided to animals while feeding on it, the material becomes acceptable to livestock even though its chemical and physical properties are not altered and so neither is its palatability. This apparently arises from the improved digestibility of the material when fed together with a nitrogen source. Potentially palatable feed can be unacceptable, and unpalatable feed can be made acceptable. Another example is the use of molasses to improve the acceptability of low quality unpalatable hay or soil pasture. Acceptability has generally been found to be positively correlated with the concentration of protein, energy, minerals, ether extract and water content and negatively correlated with fiber and lignin contents of the forage.

Acceptability is also strongly influenced by the physical properties and structure of the plant. In grasses for example, selection by both cattle and sheep has been found to be negatively correlated with leaf strength. Plant structure may influence acceptability by affecting the accessibility of leaf to the grazing animal. Thorns and spines may reduce the acceptability of certain woody browse species below levels expected from their leaf nutrient content.

Acceptability may also be reduced by the presence of awns, hairs or stickiness and by the coarseness or harshness of the leaves. Plant secondary metabolites, such as tannins and alkaloids are common amongst woody browse species and may significantly depress their acceptability to browsers such as goats.