taken in October, while in subsequent years two cuttings during end of August or early September and end of October or early November may be taken depending upon the rainfall.

After harvesting of grasses and legumes, hay may be prepared and it should be baled to reduce the volume of loose grass. It makes transportation and handling easy and economic.

After 4-5 years the pasture component may be utilized *in situ* by controlled grazing.

Management of the Pastures

Grasslands have to be managed so that they have full ground cover and provide a sustained yield of fodder grasses thereby provide cheap, nutritious and palatable forage to animals. The following practices need to be observed.

1. *Burning*

Burning is an important operation for the removal of old growth and to promote new growth of the herbage. Burning should be done in rotation from piece to piece. It should preferably be done in the dry season, just before monsoon. It also destroys eggs and larvae of parasites and worms, which cause many diseases and disorders in cattle. Burning is not likely to be detrimental to buried seeds in spear grass pastures and even non-combustible seeds lying on the surface are not likely to be affected by high temperatures of such short durations (page no. 59 of Chatterjee and Das, 1989). It has been observed that spear grass seeds survive fire by getting buried in the topsoil with the aid of hygroscopically active awns. The heat of the fire promotes its germinability. Similarly, *Themeda triandra* protects through its hygroscopic corkscrew like awns, which drive the seeds about 2.5 cm deep in the topsoil. A preponderance of spear grass under a regime of moderate grazing and annual burning has also been observed in the *Sehima-Heteropogon* grasslands at Jhansi.

2. *Weeding and clearance of undesirable plants*

If nonedible plants are removed, the production of high quality herbage will be increased over and above the removal of dangers emanating from grazing on poisonous plants. One of the best methods of removing weeds is to uproot them before flowering. Several weedicides are also available which may kill a group of plant species.

Herbicides

(a) 2, 4-D (2, 4-dichloro-phenoxy-acetic acid): It is used for the selective control of broad-leaved weeds. It kills dicotyledonous plants and is used for controlling weeds in wheat, rice, etc.

(b) 2, 4-DB (2, 4-dichloro-phenoxy-butyric acid): Its phytotoxic action relies on an enzyme system within the plant to convert it to lethal amounts of 2, 4-D, particularly in leguminous plants.

(c) 2, 4, 5-T (2, 4, 5-trichloro-phenoxy-acetic acid): It is closely related to 2, 4-D and is more effective than 2, 4-D on most woody plants, but is often less active than it (2, 4-D) on herbaceous species. Stump treatment with 2, 4, 5-T alone or in combination with 2, 4-D in the ratio of 1:2 or with Sponotox (mixture of 2, 4-D and 2, 4, 5-T containing esters of low volatility in the ratio of 2:1), prevented resprouting.

(d) Picloram (4-amino-3, 5, 6-trichloro-picolinic acid) has proved valuable in the control of a wide range of weed and brush species which are tolerant to 2, 4, 5-T. Grasses are unaffected at normal application rates, but tropical pasture legumes are very easily killed. Consequently, picloram cannot be used for overall spraying in grass or legume mixtures. Moreover, this chemical is the most soil-persistent of all the organic herbicides and must be used with great caution.

(e) Dalapon (Sodium salt of 2, 2'-dichloro-propionic acid), amino-triazole (3 amino-2, 5 dichloro-benzoic acid) and a mixture of Dalapon and Amino-triazole were tried to control *Desmostachya bipinnata*, an unwanted grass.

(f) Sodium salt of trichloroacetic acid reduced the population of *Sacchanum spontaneum* weed.

(g) Promising weedicides for controlling weeds in forage crops:
  (i) Atrazine in sorgum (M P Chari) and *Pennisetum pedicellatum*;
  (ii) Simazine in maize and teosinte;
  (iii) Trifan in cowpea;
  (iv) MCPA and Linuron in oats.

3. *Grazing management*

Grazing is by far the most important one in the management of pasture. In successful management, both overgrazing and undergrazing should be avoided. If the pasture is undergrazed and the plants are allowed to mature,

the forage becomes unpalatable and low in nutritive value and new growth is also diminished. On the other hand, overgrazing reduces the general yield. It weakens many of the best grasses in the pastures because there will be no opportunity to store enough food material for regeneration and so they die out. Weeds and coarse grasses generally predominate and quickly get a foothold in the pasture.

The number of animals to be carried per unit area is the most important factor that influences pasture productivity. The number of all livestock should be restricted to the carrying capacity or stocking rate of the grasslands. The carrying capacity of the grasslands means the number of unit animals that may be allowed to graze with no adverse effect on the grassland. It is the number of animals that can graze in a unit area without overgrazing or undergrazing in an average season. It is also expressed as number of acres needed per animal in an average season.

Maintenance of sward vigour: If soil moisture and nutrients are in good supply and the temperature is warm, good growth will depend on having an adequate green surface area to intercept sunlight and on keeping the leaves at an active stage of growth. Heavy grazing causes maintenance of less green leaves, and very light grazing causes maintenance of old leaves and stems in the pasture. Unless seeding is needed to increase plant population per unit area, keeping of pasture plants vegetative, through regulated grazing is advantageous.

Systems of grazing

(i) **Continuous grazing:** It has often been criticized as detrimental to the vegetation and it is an important cause of grassland deterioration. However, the cause of deterioration commonly has been due rather to heavy grazing and/or poor distribution of grazing. Controlled continuous grazing is a better option; or the 'deferred/delayed/rested' grazing systems.

(ii) **Controlled continuous grazing:** Uncontrolled, continuous grazing leads to depletion of desirable grass species, leaving only weak and stunted specimens of undesirable plants. So controlled grazing even if it is continuous can mitigate this effect to a great extent. The grazing is stopped when a certain minimum number of preferred plants are still left, with sufficient seed stock. This system would permit a progressive development of grassland area.

(iii) **Deferred grazing:** The objective of deferment is to increase seed production, enhance seedling establishment, and protect plants susceptible to trampling damage and defoliation and to prevent

overgrazing during low forage availability in early spring. This system is applicable when perennial grasses are predominant. Grassland is divided into 3 compartments. One compartment is completely closed to grazing during the growing season, while animals are allowed to graze in the other two compartments alternatively. Grazing is allowed in the closed one later. Grazing after seed production, in addition to utilizing the forage crop, is suggested for trampling the seed into the soil while the coarse, standing plant materials are eaten or trampled into the soil surface and thus, favouring good germination.

The grass in the 'deferred' plot, though less nutritious, makes up for it by its greater quantity. Each year one compartment is deferred in this manner, so that in 3 years, each compartment gets adequate period of rest, during which the plants could recoup their vigour. In deteriorated grasslands, where the perennial grasses are in a badly weakened condition, grazing can be deferred for 2 years in each compartment or until the desired improvement is seen. Deferred-rotation grazing in Texas (USA) is commonly referred as Merril grazing system; elsewhere it is also called as Santa Rita grazing system.

(iv) **Rotational grazing:** It consists in allowing the grazing animals into different subunits of the grassland area in rotation at suitable intervals during grazing season, so as to bring about uniform grazing without making it too close.

Advantages: 1. Animals get nutritive, young herbage; 2. Provides a period of rest during grazing season.

Disadvantage: No chance for seed formation.

There are several variants of rotational grazing.

(a) **Paddock grazing:** The grazing land is divided into paddocks where the animals would normally only spend 1 day at a time. The animals are systematically moved from one paddock to another when pasture height is about 8-10 cm.

(b) **Strip grazing:** Another way of rotational grazing is to divide the field into strips. It is also known as Hohenstein system. It involves moving livestock every 1 to 3 days (or even every half day) to a new grazing unit of fresh herbage. Pasture is divided into strips or small paddocks with movable fences (often consisting of a single strand of electric fence). This strip grazing ensures complete forage harvesting minimizing the trampling losses.

(c) Leader-follower system: This system helps to overcome the problem of inadequate grass for high-yielding cows. Here, a herd is divided into high- and low-yielding groups and the former graze the paddocks or strips of pasture first. Animals select palatable (and may be nutritious) species while grazing. Rotational and deferred grazing is important to save those species. Strip grazing is important to make the animal feed on less palatable grasses as well.

4. *Soil and water conservation*

Most of the grasslands owned by community and government are in a seriously eroded condition. Large herds of animals graze in these grasslands, reducing the surface cover and exposing the mineral soil. During grazing and movement, the animals follow different paths that are evidenced by loss of vegetation. Due to soil compaction, the permeability is reduced considerably, resulting in higher surface run-off. Continuous higher run-off causes different types of erosion in different intensities. Therefore, it is necessary that all grassland improvement programmes should invariably include soil and water conservation activity.

Soil and water conservation helps in increasing the growth of all vegetation including grasses. These operations include: contour furrowing and strip ploughing of land, plugging of *gullies* and *nalas*, preparation of bunds, etc. Sowing of seeds of *Cenchrus ciliaris*, *Cenchrus setigerus* and *Stylosanthes hamata* in 'U'-shaped furrows and closure for six months have increased the yield of grasses substantially in these areas (Kulkarni, 1979).

In Rajasthan, shallow contour trenches (22.5 cm deep and 60.5 cm wide with an interval of 10 m), contour bunds (60 cm high, lower base 187.5 cm, upper base 15.2 cm, height interval, 60.5 cm) and deeper contour trenches (30.5 cm deep, 60.9 cm wide, height interval of 60.9 cm) were made in grasslands and it was found that construction of shallow contour trenches resulted in several-fold increased grass production (Verma, 1975)

5. *Protection*

Cattle-proof trenches, live fencing with thorny species (*Acacia nilotica*, *A. catechu*, *Carissa spp.*, *Agave sislana*, *Prosopis chilensis*, and *Euphorbia spp.*) or four-strand barbed wire fencing around the grassland may be used to protect the grassland from livestock to have a controlled grazing.

6. *Introduction of improved fodder grasses and legumes*

Excessive grazing and fire destroy the palatable perennial fodder grasses in the grasslands. Only coarse annual grasses grow in such grasslands.

Introduction of high-yielding, palatable and perennial grasses becomes an essential component of any grassland development programme. Leguminous fodder species fix nitrogen from the atmosphere and hence, are capable of growing in poor and eroded sites. Fodder from these grass-legume associations is more nutritive. Moreover, some species such as *Pueraria* provide an excellent soil cover and protect the soil from erosion. In *Sehima-Heteropogon* grasslands at Jhansi, introduction of local legume, *Atylosia scarabaeoides* and an exotic legume, Siratro has been standardized. The protein content was raised from 2.1 to over 6% in the mixed herbage. Broadcasting of pelleted and scarified seeds with 20 kg P/ha in the premonsoon, with or without harrowing, gave a good establishment of the legumes. Use of grazing animal as a seed-disseminating agent has given a very good lead. This has great significance for inaccessible areas with steep slopes.

7. Application of manures and fertilizers

Grasslands are usually degraded sites. The introduction of improved varieties of grasses will not show success without the application of manures and fertilizers. Organic matter is low in most Indian soils, except in forest soils on the hills and in marshy soils. This nitrogen deficiency, therefore, needs to be rectified. Forage crops are benefited by nitrogen even more than grain and cash crops because it is the vegetative portion that is utilized as forage and N has the greatest effect on the shoot system. A grass crop of two tonnes will remove about 90 kg of N and higher yields will naturally remove greater quantities of N. Grasses require large quantities of N unlike legumes. Growing grasses in association with legumes is therefore advantageous.

Grasses can be made more nutritious by adequate manuring. Application of N at @ 224 kg/ha increased the CP content of Rhodes grass from 10 to 14.3% and *Cenchrus ciliaris* from 7.5 to 12.2%. N application in conjunction with phosphates the response is even greater. Phosphate by itself had hardly any response. In case of leguminous crops, nitrogenous fertilizers have little effect on the yields or protein content. Phosphates and potash are of greater importance to legumes than nitrogen. Legumes need more sulphur than cereals as they contain more protein.

Besides these elements, Mn, Cu, Zn, Fe and Md may also be found necessary in certain soils under certain conditions. But as a general rule they are present in all normal soils, especially, if they receive additions of organic manures like Farm Yard Manure, compost or green leaf manure.