maintained only on grazing. The '*Kutti*' consisted of chaffed sorghum straw, rice/wheat bran and oil cakes (groundnut cake/cotton seed cake etc). The concentrates and chaffed sorghum straw are usually mixed at 1:2 or 1:3 proportions, respectively. These feedstuffs are mixed manually after adding 10-15% water. This type of complete feed, called locally as *kutti* was prepared, stored overnight before feeding. About 3-4 kg of *kutti* was being fed to the animals at the time of milking. Common salt is added to kutti but mineral mixture is not included (Anonymous, 1989).

Crop Management Factors that Affect the Productivity and Quality of Crop Residues

The yield and quality characteristics of crop residues are determined by the genetic makeup of the crop and non-genetic factors (environmental, crop management and post-harvest techniques). Reddy et al. (2003) reviewed the role of various crop management interventions that can be employed for improving the yield and quality of different crop residues. These include crop management factors (seed rate and population density, time of sowing, fertilizer application and cultural practices such as irrigation and weed control), stress factors (abiotic-drought, salinity, temperature, day length; biotic-diseases and pests), intercropping and genetic factors that control fodder quantity and quality.

1. *Crop husbandry factors*

Optimum seed rate recommendations gave higher fodder yields though crop residue quality was not affected. By following optimum sowing date/ season, optimum growth conditions are ensured and pests and diseases can be avoided.

Nitrogen assumes greater importance in improving the yield and quality of crop residues of cereals. Application of N up to 120 kg/ha increased the green forage, dry matter and CP contents (HCN content also in one study) and decreased NDF content. Phosphorus and potassium do not have similar significant effects on fodder yield and quality as nitrogen. Protein content and yield were unaffected by P_2O_5 application. Crude fibre decreased with increasing N but was unaffected by P application. Application of zinc and FYM increased forage digestibility. Experiments conducted by ILRI-ICRISAT to investigate the effect of soil fertility on yield and quality of crop residues of dual-purpose sorghum cultivars revealed that grain and fodder yields were greater at high fertility; experiments with rainy season (kharif) crop showed that the sugar % was higher under low fertility, while fertility level had not affected nutritive quality traits in the post-rainy season (rabi) experiment.

Application of 60 kg P_2O_5/ha improved forage yield and quality in cowpea and other pulses in general (N need is reduced as it is fixed through symbiotic association with the plant). However, soybean needed a N dosage of 60-90 kg/ha and green gram (*Vigna radiata*) needed a higher P_2O_5 dosage of 75 kg/ha. With regards to P and K, a dosage of half that of N is generally recommended in cereals. Similarly, in pulses, N and K dosage of half that of P maximized the yields of crop residues. Nutrient fixing microorganisms, organic matter (FYM) and sullage decreased the fertilizer requirements.

Water is one of the essential inputs for crop production. It affects crop performance not only directly but also indirectly by influencing nutrient availability, timing of cultural practices. Green fodder yield of forage sorghum ranged from 38.3 t/ha with no irrigation to 88.4 t/ha with 56 mm of irrigation. Greater benefit was observed from splitting the same quantity of irrigation water into more frequent irrigations. Nitrogen, phosphorus and potassium contents in sorghum leaves increased significantly. Increased dry matter yields were obtained by irrigating every 7 days instead of each 15 days. When water is limited, it should be applied at critical stages (tillering, flowering and grain formation stage). For obtaining higher haulm yield of groundnut, two irrigations at the first phase of flowering and at pod initiation were recommended.

Weeds compete with the crop for all essential nutrients and cause stunted growth and reduction in grain and fodder yield. Hence, controlling weeds can augment the yields. Manual weeding effectively controls weeds. But chemical weeding proved to be the most economical method. The chemicals (weedicides) differed for different crops as mentioned in parentheses: sorghum (atrazine), pearl millet (atrazine and terbutryne; propazine), maize (atrazine; pendimethalin), rice (butachlor and 2, 4-D in 60:40 and anilofos), soybean (alachlor).

2. Stress factors

Sorghum exhibits drought avoidance mechanisms. Under drought conditions, sorghum yields more digestible organic matter per hectare than maize. Water-stressed sorghum plants had a higher proportion of leaves and a lower proportion of stems, which were more digestible and had lower percentage of lignin. Water-stressed tropical grain legume plants had higher digestibility and nitrogen content but had less phosphorus content

(2). stress Factors

→ water stress : Improve quality but reduce yield

→ Salinity stress : Reduce quality and yield

Barley → oat → sorghum → Pearl millet

Salinity tolerance ⟶

→ Insect - Pest and disease damage.

(3): Inter cropping Factors.

(4): Genetic Factors.

than irrigated plants. Occurrence of drought during crop growth stages improved fodder quality but reduced fodder yield. Millets also come under drought tolerant crops.

Data of green forage yield indicated that barley was most tolerant to soil salinity followed by oats, sorghum, pearl millet, Egyptian clover and maize. In sorghum, salinity decreased seed germination and early seedling growth. Salt stress reduced sorghum leaf weight and CP content. Salinity reduced both the yield and quality of crop residues. In saline soils, stress tolerant crops like barley and oats should be cultivated.

Several pests and diseases are known to reduce the productivity and quality of grain and crop residues in several crops. Sorghum is subjected to several destructive diseases like anthracnose (*Colletrotrichum graminicola*), rust (*Puccinia sorghi*) and leaf blight (*Exserohilum turcicum leo*) which directly affect the palatability as they affect the main forage fraction (foliage and stalk). An experiment was conducted to study the effect of feeding healthy versus diseased sorghum stover on the nutritive value in buffaloes (Ramteke et al., 2002). The respective stovers were procured from ICRISAT, Patancheru and experiment was conducted in the College of Veterinary Science, Hyderabad. The chopped stovers were fed for a period of 21 days to buffalo bulls (233 kg) along with groundnut cake and digestion trial was conducted. The digestibility coefficients of healthy and diseased sorghum stovers were calculated by difference method. The chemical composition and nutritive value of healthy and diseased stovers are presented in Table 10. The decreased CP and NFE and increased fibre components in diseased sorghum stover as compared to healthy stover reflects the lower leafy fraction and higher stem portion of the diseased plants. It is concluded that the nutritive value of diseased plants is lower as compared to healthy plants.

3. *Intercropping*

The low CP of crop residues is a serious constraint to livestock nutrition. Integration of forage legumes into cereal-based cropping systems is considered a promising option for addressing this constraint and for developing sustainable cropping systems. For nutritious fodder production, various intercrop combinations have been investigated such as sorghum with cowpea/pigeonpea/lablab bean/soybean/chickpea. Sorghum in rotation with any legume crop produced high yields without N fertilizer. The forage CP increased in the presence of the legume. Such an intercrop also improves soil fertility parameters. Sunhemp contributed to maximum CP content. But to achieve both high dry matter yield and CP content, cowpea is suggested as the best associate for sorghum. Crude protein contents of legume, cereal-legume and cereal fodder crops are in the range of 15.2-16.4, 11.5-12.4 and 7.9-8.1%, respectively on dry matter basis.

4. Genetic factors controlling fodder yield and quality

Varietal differences for crop residue quality have been reported in wheat, rice, barley, oats, finger millet, sorghum and maize. Certain traits such as brown midrib have been found to be associated with lowering of NDF, hemicellulose and ADL concentrations and increase of *in vitro* organic matter digestibility in crops such as sorghum and pearl millet. Straw quality is often expressed as digestibility. Studies with varieties of rice, wheat, barley, sorghum and millets grown under similar conditions have indicated wide differences in *in vitro* digestibility by as much as 10-15% units. A very important determinant of chemical composition and digestibility of straw in some crop species is the leaf to stem ratio. This is because leaves are generally higher in nutritive value (N content of leaf is more than that in stem. NDF content of leaf is lesser than that of stem in wheat, sorghum and finger millet while in case of rice the NDF content of leaf is more) and are more acceptable to animals compared to stems as leaves are more easier to

Table 10 Chemical composition (% DM) and nutritive value of healthy and diseased stovers

Attribute	*Healthy stover*	*Diseased stover*
DM	90.75	87.56
CP	5.40	3.91
EE	0.99	1.00
Total ash	6.22	6.07
CF	33.05	38.20
NFE	54.34	50.82
NDF	66.96	69.57
ADF	47.59	48.86
Hemicellulose	19.37	20.71
Cellulose	35.03	38.41
Lignin	10.17	9.03
Silica	2.39	1.42
DMI, % BW	1.85	1.70
DCP, %	2.29	1.03
TDN, %	49.3	45.33

Factors Affecting Productivity and Quality of Fodder Crops

(I). Crop Husbandry factors

(i). Sellection of Variety
- → True To Type
- → Possess good germination capacity
- → Free from seed of other species
- → graded To Uniform Seed size.
- → Free from weed seed and disease seed

(ii). Land Preparation

(iii). Seed rate

(iv). Sowing Time

(v). Fertilizer Application.

(vi). Effect of irrigation Application

(vii). Weeding

(viii). insect - Pest control

(ix). Effect of cutting stage.