5.3 FINGER MILLET

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INTRODUCTION

Finger millet (*Eleusive coracana*) is an important staple food in Southern Asia and parts of East and Central Africa. Compared to other cereals, the great merit of finger millet is that it can be stored for long periods (according to some, 10 years or more) without deterioration or insect damage. The grains form a staple food for the farming community and the stover is a source of dry roughage for the feeding of animals in areas with unreliable rains and marginal soils. The production and agronomy of finger millet will be briefly reviewed and after that, the value and use of finger millet straw as animal feed is discussed.

PRODUCTION AND CULTIVATION

In India, finger millet is cultivated in several states, and Karnataka alone accounts for more than 40% of the national production (Table 1). The straw of finger millet is considered to have a higher nutritive value than slender straws such as from rice and wheat.

Handbook for Straw Feeding Systems
Kiran Singh and J.B. Schiere (eds.), 1995
ICAR, New Delhi, India

Table 1. Production of finger millet grain and fodder in different States (five years average 1981-85)

States	Local names	Grain area (*1000 ha)	Grain production (*1000 mt)	Fodder production (*1000 mt)
Karnataka	Ragi	1056	1208	3268
Tamil Nadu	Ragi	235	327	886
Andhra Pradesh	Ragalu	240	243	659
Orissa	Mandia	281	669	669
Maharashtra	Nagali	225	649	649
Uttar Pradesh	Mandika	162	445	445
Bihar	Ragi	142	225	225
Gujarat	Nagali	46	124	124
Madya Pradesh	Marwah/ Ragi	23	15	15

Source: Technology for increasing finger millet and other small millet production in India (ICAR 1988) Project Coordinating visit. All India Coordinated Small Millets Improvement Project. G.K.V.K. Campus, Bangalore

Finger millet is cultivated on different soil types but mainly on red and laterite soils. Alluvial and black soils are also suitable, provided they are well drained. The crop is cultivated mostly in the rainy season under dryland conditions. Out of a total area of 2.6 million ha, only 0.35 million ha receive irrigation. As a dryland crop, finger millet is sown in July in the southern parts of India. In the North, it is sown in May-June. Men, women and children have specific roles in the cultivation and harvesting depending on class, social status and region. Table 2 shows the gender division of labour and the role of bullocks in the cultivation of finger millet in a village near Bangalore.

The choice of varieties depends on the agroclimatic situation of the region. In the northern states, particularly at higher elevations, early maturity (90-

100 days) types are required. Medium and late duration varieties are preferred in the plains and the southern states because of photoperiodicity of the region.

Table 2. Gender division of work in the cultivation of finger millet (adapted from Vijayalakshmi and Seetaramaswami, 1994)

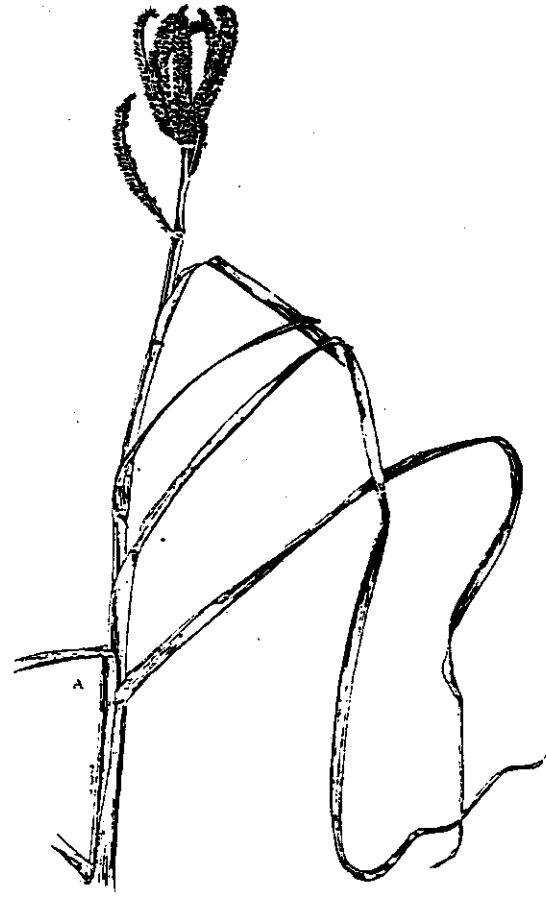
Activity	Men	Women	Bullocks
Cultivation:			
ploughing	+++	-	+++
cold crushing	++	++	-
harrowing	++	-	++
manuring	+++	+++	++
Plant care:			
sowing (dry land)	++	++	++
sowing (irrigated)	+	++	-
weeding	+	+++	+
thinning	++	+	++
irrigation	++	++	-
harvesting	+	+++	-
Post harvest:			
collection	++	+++	++
transport			
stacking			
threshing	++	+	+++
cleaning	+	+++	-
storage	++	++	-

- = no contribution; + = small contribution; ++ = medium contribution; +++ = large contribution

Under dryland conditions finger millet is often sown by broadcasting the seeds at the rate of 25 kg/ha. After two weeks when the plants are about 2-3 cm tall, they are thinned to reduce the plant density. The thinnings can be used as animal feed. When sown in rows, optimum spacing recommended

for best yields is 25-30 cm and a plant to plant spacing of 10 cm for dry land. Denser planting results in less grain but more fodder and thinner steams, i.e. better stover. Generally, in southern India, finger millet is intercropped with crops like fodder sorghum (jowar), field beans, niger, castor and pigeon peas and in some places even with pearl millet (bajra). Finger millet is also rotated with other dry land crops like groundnut, horse gram, other millets, cotton, tobacco and oil seed crops like sesame.

Figure 1. Flowering shoot of finger millet (adapted from Purseglove, 1972)



Under irrigated conditions, finger millet is mostly grown after paddy when the water availability is not sufficient for a next crop of paddy. It is also grown after crops like sugarcane, potatoes, onions, carrots and chillies. However, with the adoption of modern management practices, finger millet is also grown as a sole crop.

Genetic variation in grain and fodder yield

Short duration varieties are semi dwarf, with a lower grain/straw ratio, higher proportion of cell contents, less cell walls, and therefore a higher organic matter digestibility than medium and late duration varieties (see Table 3). The higher harvest index (HI) of the longer duration varieties results in less cell solubles and a lower nutritive value of straw (#3.3.).

Table 3. Grain and fodder yield, chemical composition and *in vitro* digestibility of early, medium and late varieties

Characteristic	Variety		
	Early	Medium	Late
Grain yield (kg/ha)	3800	4900	5500
Fodder yield (kg/ha)	6100	6400	7300
Harvest Index	0.39	0.44	0.44
Height (cm)	89	101	115
Organic matter	90	91	91
Crude Protein	4.4	3.4	3.4
Cell wall content	60	63	65
OM digestibility (%)	62	59	58
Cell wall digestibility (%)	43	41	41
TDN (%)	56	54	52

Fertilizer and manures

The recommended fertilizer levels vary from state to state, but the general dosage (kg/ha) of N:P:K is 50:37.5:25 for dryland and 100:50:50 for irrigated land. Phosphorus and Potassium are applied at the time of sowing, while Nitrogen is ideally applied in two split doses i.e. 50% at the time of sowing, and the remaining 50% at 40-45 days after sowing. Application of farmyard manure reduces the fertilizer requirements and helps to improve the physical properties of the soil.

Table 4. Biomass, height and quality of finger millet straw, some approximate values

Criteria	Rainfed			Irrigated		
	Levels of N:P:K					
	F-I	F-II	F-III	M-I	M-II	M-III
biomass(1000kg/ha)	9	10	12	8	14	16
height (cm)	46	54	58	73	90	95
organic matter (%)	92	92	92	90	90	89
crude protein (%)	5	5	5	4	4	4
cellwall content	67	67	67	62	62	63
IVOMD (%)	59	59	61	61	60	60

Note: Rainfed: F-I(0:0:0) F-II (25:20:13) F-III (50:40:25)
Irrigated: M-I(0:0:0) M-II (50:25:25) M-III(100:50:50)
Source: Technology for increasing finger millet and other small millet production in India (ICAR 1988) Project Coordinating Unit. All India Coordinated Small Millets Improvement Project. G.K.V.K. Campus, Bangalore

The effect of fertilization on straw quality and quantity

In experimental work, the biomass production of grain and fodder per hectare and the plant height increased with the level of application of NPK

(Table 4). The organic matter content (%) remained unchanged with increasing level of NPK application. There is no significant effect of fertilizer application on the organic matter digestibility of the straw.

Effect of location on straw quantity and quality

Finger millet is grown at locations with different rainfall had different stover biomass yields (Table 5). Stovers from higher rainfall areas generally have lower crude protein levels, but higher cell wall contents. There were no differences between locations in organic matter digestibility, whereas the location effect was significant on the cell wall digestibility.

Table 5. Morphological characteristics, chemical composition and *in vitro* digestibility

		Location		
Parameter	**Range**	**Coimbatore**	**Vizayanagaram**	**Bangalore**
Grain yield (1000 kg)	3-6	1.3	1.8	5.0
Plant height (cm)	57-117	73	81	94
Composition(%DM):				
Organic matter	83-90	88	88	88
Crude Protein	3-11	9.5	3.8	6.9
CWC	58-72	64	68	66
In-vitro Digestibility(%):				
Organic Matter	43-62	51	52	51
CWC	26-45	34	37	35
TDN	45	45	46	45

Weeds, diseases, insects and pests

Most of the weeds commonly observed in finger millet belong to the grass family and timely weeding is important, this would provide a source of feed at the same time. Finger millet is affected by fungal and viral diseases, but insects and pests are not so common. Stem borers, aphids and caterpillars can at times cause considerable damage.

Table 6. Difference in harvest characteristics of traditional and improved finger millet cultivars

Cultivars	Total Dry Matter (g/m^2)	Grain:stem ratio	Harvest Index
Traditional	650-1500	26:74	0.21-0.33
Improved	1240-1400	42:58	0.40-0.41

Strategies to improve grain and fodder yield

In spite of its importance, the production of grain and stover is only 1000 kg of grain and 3000 kg of straw per ha. This is low as compared to other food crops, mainly due to marginal methods and conditions of cultivation; finger millet being a crop that thrives when other grains cannot grow well any more. Inputs like improved seeds and fertilizers are used only sparsely. Further, the breeding of finger millet for grain only has decreased the fodder yields. The local cultivars (land races) which are cultivated as fodder types had a low harvest index (HI = 0.21) and improved dual purpose cultivars and hybrids developed for grain purpose have a HI of around 0.40 (Table 6). Since farmers view grain and fodder as equally valuable, especially in conditions where finger millet is grown, it is essential to explore ways to

increase both grain and fodder yield, in terms of quantity and quality.

A number of hybrid varieties is not preferred by the farmers since the stems are thicker and animals leave more residues as compared to local varieties (#4.4.). Laboratory studies show that both the land race and improved cultivars have comparable organic matter digestibility, but crude protein content is higher in local varieties. Proper matching of laboratory measurements and farmers perceptions of stover quality and total plant output deserves attention in research and extension (#3.3.).

Harvest

The crop is harvested at grain maturity. The general practice is to harvest the plants 3 cm above ground level and they are left in the field to wither; sometimes they are tied to sheaves and stacked to dry. Under irrigated conditions, the ears do not mature simultaneously. Earheads are gathered as they mature, heaped for 45-60 days to cure. Straw is then harvested on drying. In both cases grains are separated using either bullocks or passing heavy stone rollers. The grains are stored for human consumption.

Straws left in the field after removal of ear heads decrease significantly in nutritive value, probably due to loss of cell solubles. Straws harvested at grain maturity and stored under a roof do not change in quality as much (Table 7). In terms of nutritive value it is therefore worth to consider harvesting straw at grain maturity for subsequent proper storage (dry and protected from sun/rain).

Table 7. Chemical composition (on DM basis) and digestibility of finger millet straw on storing

Stages	Organic matter	CWC (%)	IVOMD (%)	IVCWD *) (%)
Grain maturity	89	66	61	48
10 days after grain maturity	90	68	57	43
60 days on storing	89	71	50	38
150 days on storing	88	70	49	36

*) IVCWD, *in vitro cell wall digestibility*

Leaf to stem ratio

The high yielding grain type cultivars show less tillering, but larger earheads as compared with fodder types (Table 8). The latter have thin stems with high tillering and small earheads. The modern high grain yielders have thick stems and a low leaf to stem ratio.

Table 8. Leaf to stem ratio of different types of cultivars

Type of cultivar	HI	leaf:stem ratio
Fodder type	0.22-0.25	30:70
Grain type	0.32-0.33	25:75

NUTRITIVE VALUE

Feeding trials on finger millet straw conducted at NDRI (Bangalore), showed considerable variation in chemical composition and in intake (Table 9). The

accessions from Indian and African origin differed in organic matter, crude protein and cell wall content, within as well as between origins. Organic matter and cell wall digestibility varied among cultivars.

The cause for such variation in straw composition and digestibility may lie in the proportion of morphological fractions (#4.5.). In finger millet straw, the cell wall content in leaves (66%) is lower than in stems (71%), while cell wall digestibility is higher in leaves (51%) than in stems (33%).

Bullocks consumed daily 4-6 kg, heifers 3-5 kg and milch animals 6-8 kg of finger millet straw when fed without supplements.

Table 9. Chemical composition and dry matter intake of finger millet straw.

Chemical composition (%)	
organic matter	89-92
crude protein	3-5
crude fibre	34-39
cell solubles	10-21
water soluble carbohydrates	3-6
calcium	0.7-1.2
phosphorus	0.05-0.21
Intake (kg DM per 100 kg BW)	
bullocks	1.6
heifers	1.7
milch animals	2.0

Farmers' perceptions on nutritive value

There is a strong belief among farmers that traditional land races are superior in terms of straw quality than the hybrids developed for higher

grain yields. Laboratory measurements do not confirm this, and the worst of the traditional varieties might be inferior to the better stovers of new varieties. Hybrids are low fodder yielders; again a general statement that may not be true across the board (#2.2.). Animals leave more residues of thick than of thin stems, such as of land race or densely planted crops. Higher phenolic content present in the straw is believed to give a bitter taste.

Table 10. Feeding systems

Feeding Systems	Remarks
Supplementation (#4.3.)	Supplementation as with all other straws
Chopping (#4.6.2.)	Finger millet stover is fed in the long form only, chopping of straw is uncommon in Southern as well as in Northern India. The method of threshing, under granite rollers, makes that the straw is shredded and chopped to some extent.
Selective consumption (#4.4.)	Feeding of finger millet straw in excess and long form, particularly to milk producing animals is common in many parts of the country. The residue, of lower quality is fed to working animals, low producing animals, and buffaloes. The final residue is used for compost
Urea treatment (#4.6.1.)	Treating straw with 4% urea using max. 100 litres. of water per 100 kg air dry straw in long form, storing it under airtight condition for a period of 1-3 weeks improves palatability, energy and protein content
Soaking (#4.6.2.)	Soaking of finger millet straw as feed is not commonly done in South India, in contrast to the soaking of e.g. rice straw in places such as Tamil Nadu.

FEEDING SYSTEMS

Traditionally farmers feed stovers along with supplements like greens, oil seed cakes, concentrates that are locally available or premixed in the market. Some feeding systems are given in Table 10.

OTHER USES

Due to its high palatability and nutritive value, farmers use the stovers almost exclusively for feeding cattle. Residues left by the cattle are used in the preparation of farm yard manure. In some parts in and near India (e.g. the hill regions of Sikkim, Nepal, Himachal Pradesh and Uttar Pradesh), after 30 to 40 days seeding, the excess seedlings are used for feeding cattle. In other parts e.g., Kashmir, Andhra Pradesh and Tamil Nadu, the animals are allowed a quick grazing to encourage tillering. Finger millet can also be cultivated as forage for feeding cattle and its nutritive value is comparable to any other cultivated grasses.

SUGGESTED READING

Kiran Singh and J.B Schiere (eds.). 1993. Feeding of Ruminants on Fibrous Crop Residues. Proc. of Intern. Workshop held from Feb. 4th-8th, 1991 at NDRI, Karnal. ICAR, New Delhi, India.

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