SHRUBS AND TREE FODDERS FOR FARM ANIMALS

PROCEEDINGS OF A WORKSHOP IN DENPASAR, INDONESIA, 24 – 29 JULY 1989

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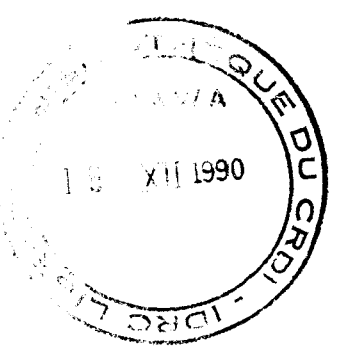

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Abstract

This publication presents the results of an international meeting held in Denpasar, Bali, Indonesia, 24–29 July 1989, that focused on the use of shrubs and tree fodders by farm animals. Through 26 papers, the workshop addressed feed-resource availability, use by ruminants and nonruminants, processing methodology, economics, and development issues. These aspects and the current knowledge on shrubs and tree fodders were further highlighted by country case studies detailing prevailing situations and policy matters. A special session was held to discuss the successful development and results achieved in the three-strata forage system in Indonesia. The workshop concluded with important working group discussions on the priorities for further research and development, and on the potential for the wider use of shrubs and tree fodders in the developing world.

Résumé

Cette publication présente les résultats d'une rencontre internationale tenue à Denpasar, Bali, Indonésie, du 24 au 29 juillet 1989 et qui a porté sur l'utilisation des arbustes et fourrages végétaux par les animaux d'élevage. Les 26 communications qui y ont été présentées traitaient de la disponibilité des ressources alimentaires pour les animaux, de leur utilisation par les ruminants et les non-ruminants, des méthodes de transformation, des aspects économiques et des questions du développement. Ces sujets et les connaissances actuelles sur les arbustes et les fourrages végétaux ont ensuite été étudiés plus à fond dans le cadre d'études de cas de divers pays exposant les circonstances particulières de chacun et les questions liées aux politiques. Une séance spéciale a porté sur la mise en place et les résultats des systèmes de production de fourrages végétaux en trois strates en Indonésie. L'atelier s'est terminé par d'importantes discussions des groupes de travail sur les priorités de recherche et de développement pour l'avenir et sur les possibilités d'utilisation élargie des arbustes et des fourrages végétaux dans les pays en développement.

Resumen

Esta publicación presenta los resultados de una reunión internacional celebrada en Denpasar, Bali, Indonesia, del 24 al 29 de julio de 1989, y la cual centró su atención en la utilización de forrajes elaborados a partir de arbustos y árboles para alimentar a animales de granjas. En 26 trabajos presentados al seminario, los participantes abordaron temas tales como la disponibilidad de recursos alimentarios y la utilización de los mismos por rumiantes y no rumiantes, metodologías de procesamiento y cuestiones de economía y desarrollo. Estos aspectos y el conocimiento que se tiene actualmente sobre los forrajes de arbustos y árboles se vieron subrayados aún más por estudios de casos por países en los que se detallaron situaciones existentes y cuestiones de políticas. Se celebró una sesión especial para discutir el desarrollo y resultados exitosos alcanzados en Indonesia con el sistema de forraje de tres niveles. El taller concluyó con importantes discusiones de los grupos de trabajo sobre las prioridades existentes en el campo de la investigación y el desarrollo y sobre el potencial que encierra la amplia utilización de arbustos y árboles en el mundo en desarrollo.

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Session IV: Country Case Studies

Session V: Processing, Methodology, and Economics

Availability and use of shrubs and tree fodders in India

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Abstract *— Ruminants feed widely on shrubs and tree leaves rather than on grass or grass legume pastures in India. Some tree fodders are almost as nutritious as leguminous fodders. Data is presented on nutritional aspects of tree leaves and their patterns of use by animal species. The data suggest the necessity for integrated, intensive efforts to cultivate and propagate shrubs and tree leaves. The critical limitations and constraints to use require, however, more intensive research for economic feeding. Government policies concerning the production of these feeds require an integrated approach involving scientists and government departments concerned with fodder tree production for animals.*

Résumé *— En Inde, les ruminants se nourrissent plus généralement de feuilles d'arbustes et d'arbres que de graminées et de légumineuses. Certains arbres fourragers sont presque aussi nutritifs que les légumineuses. L'auteur présente des données sur les aspects nutritionnels des feuilles d'arbre et sur l'utilisation de ces feuilles par les espèces animales. Les données indiquent la nécessité d'efforts intégrés et intenses pour cultiver et propager l'utilisation de feuilles d'arbustes et d'arbres. Les limites et les obstacles critiques à leur emploi exigent toutefois l'exécution de recherches intenses sur l'alimentation économique des animaux. Les politiques gouvernementales relatives à la production de ces fourrages exigent, elles, une approche intégrée dont seraient les scientifiques et les ministères gouvernementaux s'intéressant à la production d'arbres fourragers pour les animaux.*

Resumen *— En la India, los rumiantes se alimentan en gran medida de hojas de arbustos y árboles antes que de gramíneas o hierbas leguminosas. Algunos forrajes de árboles son casi tan nutritivos como los forrajes de leguminosas. Se brinda información sobre los aspectos nutritivos de las hojas de árboles y las formas en que las utilizan las especies animales. Los datos sugieren la necesidad de hacer esfuerzos integrdos e intensivos para cultivar y multiplicar hojas de arbustos y árboles. Sin embargo, las limitaciones y restricciones decisivas de su uso requieren una investigación más exhaustiva para encontrar una alimentación económica. Las políticas gubernamentales con respecto a la producción de estos alimentos exigen un método integrado que involucre a científicos y departamentos del gobierno ocupados en la producción de árboles forrajeros para animales.*

Introduction

In India, there is a huge annual shortage of concentrates (44%), green fodders (36%), and dry roughages (36%) for animal feeds. This situation is caused by periodical rainfall, confined to the monsoon season. These estimates do not, however, include feed resources from shrubs and tree leaves. Tree leaves are commonly referred to as "top feeds" and are often considered as emergency livestock fodder; they contribute to the staple feeds of small and large ruminants in India. These feeds are particularly valuable for goats, whose population in India ranks first in the world. For this species, shrubs and tree fodders contribute more than 60% of total feed.

Value of shrubs and tree leaves

In many parts of India, more animals feed on shrubs and trees than on surface fodders like grasses and grass–legume pastures. The leaves are useful as protein supplements to straws and other low-protein fodders. Dry, deciduous vegetation is mostly found in semi-arid regions and is confined to the northwest area of the Indian subcontinent. In this complex of vegetation, trees predominate and shrubs form the important second or third tier of the stand. Tropical thorn forests are also found and are spread throughout the arid and semi-arid regions of India. The southern regions have a more gravelly stratum, where the shrubs are sparse in comparison to the north.

In hilly areas, livestock are maintained mostly on tree loppings. Generally, the dry matter content of the various tree leaves varies from 20 to 40%, with 10–15% crude protein on a dry matter basis (Singh 1982). Higher values of between 20 and 23% have been recorded for leucaena (*Leucaena leucocephala*) or Su-babul (Upadhyay et al. 1974) (Table 1). The ether extract fraction is also fairly high compared with annual and perennial, natural and cultivated grasses and hays. Tree leaves contain comparatively low percentage of crude fibre compared with grasses and hays. Their fibre is complex and highly lignified at maturity. The crude protein content decreases and the crude fibre content increases with increasing age of the tree leaves (Singh 1981).

Calcium content of tree leaves is 2–3 times more than that of cultivated fodders or grasses. The phosphorus content is, in general, low, resulting in a wide calcium to phosphorus ratio (Table 1). There is a variation in tannin content, which appears to be a limiting factor in the feeding value of some tree leaves (Lohan et al. 1980). The presence of tannins has been found to adversely affect the dry matter digestibility and use of nutrients, and an inverse relationship exists between tannin content and crude protein digestibility (Lohan et al. 1980). It has also been observed that the palatability, digestibility, and nutritive value (Table 2) of tree leaves decreases (Negi 1977) as the leaves advance in maturity (Table 3).

The palatability, digestibility, and nutritive value of tree leaves are higher with goats than with sheep (Bohra 1980). Although the intakes of nitrogen and calcium are higher, their balances are poor. Phosphorus balances are negative or marginally positive in most cases because the tree leaves are low in phosphorus. The higher calcium content of tree leaves is of no value without phosphorus supplementation when feeding sheep and goats (Singh 1981).

Table 1. Proximate composition of some fodder tree leaves (% dry matter).

Species	Common name	Crude protein	Ether extract	Crude fibre	Nitrogen-free extract	Calcium	Phos-phorus	Source
Alianthus excelsa	Ardu	19.56	3.68	13.52	47.74	2.42	0.17	Singh and Patnayak (1981)
Acacia arabica	Babul	10.95	8.97	13.75	58.03	1.21	0.06	Prasad et al. (1974)
Celtis tetrenda	Kharik	14.00	4.05	16.60	44.00	4.08	0.13	Joshi and Ludri (1966)
Ficus roxbergis	Timla	13.35	4.65	7.71	64.87	1.31	0.17	Joshi and Ludri (1966)
Grewia elastica	Dhaman	19.87	9.50	11.20	47.41	2.74	0.05	Khajuria and Singh (1967)
Gymnosporia spinosa	Kankera	9.43	3.59	15.33	59.83	3.92	0.13	Mohan et al. (1977)
Leucaena leucocephala	Su-babul	21.45	6.54	14.25	49.48	2.70	0.17	Upadhyaya et al. (1974)
Prosopis cineraria	Khejri	13.98	1.88	17.80	43.44	2.73	0.15	Singh (1981)
Zizyphus nummularia	Pala	14.06	2.96	17.04	55.85	2.79	0.14	Malik and Nath (1970)

Table 2. Dry matter intake (DMI), digestible crude protein (DCP), and total digestible nutrients (TDN) of some fodder tree leaves (% dry matter).

Species	Common name	DMI/100 kg body weight	DCP	TDN	Source
Alianthus excelsa	Ardu	3.80	16.24	63.80	Singh and Patnayak (1977)
Celtis tetrenda	Kharik	4.10	9.21	40.48	Joshi and Ludri (1966)
Dendrocalamus strictus	Bamboo	2.51	9.34	48.91	Kehar and Goswami (1956)
Ficus glomerata	Gular	—	6.69	53.82	Majumdar et al. (1967)
Ficus roxbergis	Timla	1.87	6.21	57.30	Joshi and Ludri (1966)
Grewia elastica	Dhaman	3.50	15.52	71.30	Khajuria and Singh (1967)
Gymnosporia spinosa	Kankera	3.71	2.66	33.16	Mohan et al. (1977)
Leucaena leucocephala	Su-babul	4.00	16.73	70.22	Upadhyaya et al. (1974)
Morus alba	Tut	3.44	10.68	59.59	Kehar and Goswami (1956)
Prosopis cineraria	Khejri	2.18	4.49	40.99	Bhandari et al. (1979)
Zizyphus nummularia	Pala	2.05	5.56	49.70	Nath et al. (1969)

Table 3. Leaf tannin content and its relation to nutritive value.

Species	Stage	Tannin (% DM)	DM (% D)	% DM	% D	DCP (% DM)	TDN (% DM)
Grewia optiva	Early	0.0	58	20.8	76	15.8	55.2
	Late	0.0	55	20.2	67	13.6	52.3
Robinia pseudocacia	Early	2.7	41	25.1	39	9.8	38.5
	Late	1.5	48	20.6	56	11.5	42.8
Bauhinia variegata	Early	2.1	35	15.8	43	6.8	35.5
	Late	1.2	48	14.0	56	7.9	45.5
Dendrocalamus hamiltonii	Early	0.6	44	15.1	68	10.3	36.9
	Late	0.1	55	14.2	76	10.8	48.5

Note: D, digestibility; DM, dry matter; DCP, digestible crude protein; TDN, total digestible nutrients.
Source: Negi (1977).

On average, the digestibility coefficients of shrubs and tree fodders in ruminants were of about 66% for dry matter, 81% for crude protein, 35% for ether extract, 32% for crude fibre, and 78% for nitrogen-free extract for green leaves. The digestibility coefficients for crude protein, crude fibre, and ether extract were higher with dry leaves because of their lower dry matter content.

Patterns of use by animals

Fodder trees currently provide concentrates to the livestock population of both the sedentary, marginal and the nomadic farmers. The landless population who own small herds of sheep and goats depend on shrubs and tree feed resources growing near the village, roadsides, and on community lands. The trees provide valuable feeds at low cost and are easily accessible. When the sources in the vicinity of the villages are depleted, the rural women frequent reserve forest areas, sometimes walking 10–15 km in the hills to meet the daily requirements of ruminants.

The fodder trees throughout the country are lopped by local people depending on requirements for feeding. Whereas sheep prefer to graze close to the ground, goats browse on a wide variety of shrubs and lower branches of trees, leaving the upper branches for camels. Thus, these species do not compete with each other in grazing. Sheep and goats are fed loppings when the surface vegetation, including shrubs, becomes scarce, especially during the winter and summer months. Grazing management generally involves browsing by sheep and goats on waste grasses and shrubs and the feeding of fresh, lopped tree leaves. In almost all feeding experiments on shrubs and tree leaves conducted throughout India (Malik and Nath 1970; Singh and Bhatia 1982; Verma et al. 1982; Mali et al. 1984), goats used green leaves most efficiently followed by sheep, camels, and cattle.

It is also a common practice throughout India to lop and dry tree leaves when they are abundant and store them for feeding during periods when feeds are scarce. Generally, green leaves and branches are lopped, piled into a heap, and dried in the field. The leaves are separated from the twigs and branches after drying and are stored. Some of the dry leaves have also been successfully incorporated in concentrate supplements and feed-lot diets for sheep and goats.

Performance and economics

Singh (1981) compared the use of *Zizyphus nummularia* (Pala) leaves in adult sheep and goats and observed that the dry matter intakes in goats were almost double those in sheep and that the digestibility coefficients of dry matter, crude protein, ether extract and crude fibre were higher in goats than in sheep (Table 4). Bohra (1980) obtained similar results in sheep and goats fed *Prosopis cineraria*. The superior digestive efficiency, especially of crude fibre, in goats can be attributed to their slower rate of passage of digesta.

The performance of lambs and kids fed *P. cineraria* (khejri) (Singh and Bhatia 1982) revealed that kids gained and lambs lost weight under identical management conditions (Table 5). It is fairly well-established that tree leaves, when fed alone, cannot support growth although they contain 13–20% protein. They have been

Table 4. Use of *Zizyphus nummularia* by sheep and goats.

	Sheep	Goats
Intake		
Dry matter intake (g/day)	632	1 103
Dry matter intake per 100 kg body weight	2.1	3.3
Dry matter intake/$kg^{0.75}$ (g)	41.0	78.6
Digestible crude protein (g)	27.2	61.9
Total digestible nutrients (g)	311.4	531.7
Digestibility (%)		
Dry matter	41.1	45.7
Crude protein	35.6	47.8
Ether extract	20.9	35.2
Crude fibre	33.6	51.8
Nitrogen-free extract	62.2	51.9

Source: Singh (1981).

successfully incorporated into the concentrate supplements and feed-lot diets of sheep and goats because digestibility is low (20–40%). *Prosopis cineraria* leaves and concentrate mixed at 20:80 for lambs (Bhatia et al. 1976) and 50:50 for kids (Parthasarathy 1986) gave maximum growth rates of 80 and 100 g, respectively (Table 5). Tree leaves, either green or dried, when fed along with concentrates, become a valuable feed resource for small ruminants.

The pods of many fodder trees have been tested as a feed resource for sheep, goats, and cattle. *Acacia* pods are commonly fed to sheep and goats by shepherds. Likewise, pods of *Prosopis juliflora*, either green or dried, are extensively fed to sheep and goats by farmers. Gujarathi et al. (1981) studied the use of *Prosopis juliflora* in the maintenance diets of bullocks. Powdered pods have been incorporated into concentrate mixtures and pelleted feeds for sheep at a rate of up to 20% (Reddy and Reddy 1985).

During the last three decades, extensive work has been carried out to determine the nutritive value of various tree leaves; however, the economic aspects of feeding tree leaves to livestock still needs to be investigated. The costs of collecting dried leaves, processing, and weight gain and milk production should be assessed when these materials are incorporated into diets. Singh et al. (1980) estimated the cost of collecting *Alianthus excelsa* (ardu) leaves to be 15 INR/q (1 q = 100 kg) and the authors observed that cross-bred rams gained 150 g/day when fed ardu leaves with a dry matter intake of 1.8 kg (in July 1989, 15 Indian rupees [INR] = 1 United States dollar [USD]). The feed cost per kilogram weight is 2 INR, which is highly economical. In fact, this is exactly how the shepherds raise goats in India, with minimal feed cost. Shukla (1982) calculated the cost of milk production by incorporating powdered *P. juliflora* pods at 15% in the concentrate mixture and babul (*Acacia nilotica*) seed pods at 15%, and observed that feed cost per kilogram of milk was reduced by 10%.

Cultivation and propagation

Tree fodders are primarily for fuel; however, their value for feeding ruminants necessitates the planting of multipurpose fodder trees. The need to introduce exotic

Table 5. Results of four studies on the performance of kids and lambs fed shrubs and tree leaves.

Study	Feeding regime	Duration (days)	Intake (g/day)	Growth rate (g/day)
Singh and Bhatia (1982)				
Kids	Khejri leaves	50	672	46
Lambs	Khejri leaves	50	539	–28
Bhatia et al. (1976) (lambs)	Concentrates	35	268	89
	80% concentrates + 20% neem leaves	35	268	66
	80% concentrates + 20% khejri leaves	36	225	80
Parthasarathy (1986) (kids)	Khejri leaves	90	638	18
	25% concentrates + 75% khejri leaves	90	779	81
	50% concentrates + 50% khejri leaves	90	732	100
	75% concentrates + 25% khejri leaves	90	619	94
Bhatia and Ratan (1981) (lambs)	20% concentrates + 80% pala	90	548	–3[a]
	50% concentrates + 50% pala	90	654	24
	80% concentrates + 20% pala	90	648	37

[a] In 2 months, three of six lambs died under this regime.

and indigenous fodder trees in a particular region arises either because the area lacks such useful shrubs and trees, or because such species are slow in growth and unable to meet requirements (Patil et al. 1983). A large number of exotic and indigenous trees including fodder trees were introduced to the Central Arid Zone Research Institute, Jodhpur, during the 1950s. The most promising amongst the exotic fodder trees and shrubs are *Acacia tortilis*, *Cellophospermum mopane*, *P. juliflora*, *Dichrostachys mutans*, *Brasilettia mollis*, *Pittosporum phillyraesides*, *Schirueus mole*, *Atriplex* spp., and *Zizyphus spinacristi*. Among the successful indigenous introductions are *Albizia amara*, *Cardio roti*, *Albizia lebbek*, *Acacia nilotica*, *Hardwickia binata*, *Azardirachta indica*, *A. excelsa*, and *P. cineraria*.

During the 1970s, many exotic and indigenous fodder trees and shrubs were introduced by the Indian Grassland and Fodder Research Institute in Jhansi. The most promising exotic species are *L. leucocephala*, *A. tortilis*, *D. mutans*, and *C. mopane*. The promising indigenous introductions are *A. amara*, *H. binata*, *A. lebbek*, *Sesbiana sesbum*, *A. nilotica*, *Dalbergia sissoo*, *A. indica*, and *Albizia procera*. The first two species, *A. amara* and *H. binata*, have been introduced successfully into semi-arid areas (Deb Roy et al. 1980). Some of these species have also been successfully propagated in silvipastoral and agroforestry systems (Patil et al. 1979; Pathak et al. 1981).

Species suitable for various regions

It is difficult to select fodder species based only on climate; soil factors are equally important. However, an attempt was made to broadly select fodder tree species suitable for the various climates of India. Deb Roy and Pathak (1975) listed important shrubs and trees suitable for the five agroclimatic regions of India.

Propagation of fodder trees in integrated systems

Few attempts have been made to plant trees for fodder. Some systematic work on the propagation of fodder trees and shrubs was done at the Indian Grassland and Fodder Research Institute during the 1970s in various integrated systems. The Central Arid Zone Research Institute in Jodhpur has done commendable work on the cultivation of trees and shrubs for the stabilization of sand dunes and other arid habitats. In addition, techniques for the propagation of arid tracts have been standardized (Bhimaya and Choudhury 1961; Kaul and Nambiar 1966).

Silvipastoral system

Ideal trees and shrubs for a silvipastoral system are those that

- are compatible and have a complimentary effect on grasses and legumes,
- have long tap root systems with little superficial roots,
- are drought and frost hardy,
- have little or no allelopathic effect on the pasture,
- are leguminous with a light canopy during the monsoon season, and
- are resistant to pest and diseases common to pasture grasses and legumes.

Cultivation of some of the tree fodders in association with grasses and grass–legume mixtures has been standardized by Deb Roy and Pathak (1975). Deb Roy et al. (1980) detailed the technique and the performance of various fodder trees in association with grasses and grass–legume mixtures. The pasture remains green for a greater period than in the open and the grass is more nutritious. Growing heifers grazing in the silvipastoral system can maintain their body weight, even during the dry summer period, if 2 kg tree leaves is provided without any concentrates or mineral mixtures.

Forestry systems

Ideal trees and shrubs for forestry systems are those that

- have a canopy that allows more light on the ground for crop growth,
- show more leaf production during the dry periods and less leaf production during crop growth,
- have leaf litters of little allelopathic potential and quick mineralizing nature,
- have strong tap root systems with less side roots,
- are resistant to pests and diseases common to crops,
- respond quickly to irrigation and fertilization, and
- have nitrogen-fixing properties.

In agroforestry systems, some of the fast-growing fodder trees and shrubs, such as *L. leucocephala*, *Sesbiana grandiflora*, and *Sesbania sesban*, could be propagated in association with fodder and cash crops without jeopardizing their production. In farm forestry systems, fodder trees such as *L. leucocephala*, *S. grandiflora*, *Morus alba*, and *S. sesban*, were successfully cultivated along farm roads, boundaries, canal banks and riversides. Besides providing nutritious green fodder, the system produces firewood within 4 years and a coppice rotation of 3 years. The system also protects the canal and river banks from erosion. In both these systems, the soils become enriched in nitrogen, phosphorus, carbon, and sulphur over a few years despite the annual harvest of forage.

Critical limitations and constraints

Most fodder tree species are under stress because of unplanned defoliation. Socioeconomic conditions and religious beliefs in India are such that the reduction of unproductive cattle is a major constraint for formulating any well-planned policy for the systematic production and use of tree foliage. No special, systematic attention has been given to the establishment and propagation of fodder tree species; the common belief is that such resources are plentiful, which is far from truth. The Indian Department of Forestry is primarily interested in raising economically important species. The village forests today are not in good condition and, in many situations, the topsoil is being washed away, exposing rocks and losing productive capacity. These lands today are exercise grounds for the village livestock.

Some of the other constraints are the concept of land being everybody's property

but nobody's responsibility and the multiple control over community lands with undemarcated rights of the villagers and the use of community lands. The lack of peoples' participation and unrealistic goals and targets for the plantation of community lands are further constraints. The proposal for land-use legislation does not appear to provide a solution because theories and practices whose validity has been proved cannot be forced on people.

Toxicity problems

Two toxic factors commonly found in tree fodders are tannic acid and mimosine. Tannic acid affects protein metabolism (Badaway et al. 1969; Lohan et al. 1980); mimosine, an uncommon amino acid present in the leaves of leucaena, causes ill effects when ingested in large doses (Hamilton et al. 1968). Some trace minerals, such as fluorine, molybdenum, and selenium, are reported to be present in toxic amounts in some tree leaves (Gupta et al. 1982; Prasad 1982). There are also some tree leaves in the hilly areas of Uttar Pradesh, Kashmir, and Assam that are deficient in copper and zinc (Sawhney et al. 1977).

Tannins are widely distributed in plants and adversely affect the digestibility of dry matter and the use of nutrients. There is a wide variation in leaf tannin content in different tree species. Lohan et al. (1980) reported the tannin content of tree fodders in Himachal Pradesh. Negi (1977) observed that the level of tannins was higher in the early stages of growth (see Table 3) and that the higher content of tannin inhibited nutritive value. Generally, the nutritive value of tree leaves should decline with increased maturity (Majumdar et al. 1967); however, only *G. optiva*, with no tannins, showed such a trend. In others, higher levels of tannins depressed the digestibility of both dry matter and crude protein because of their inhibition of proteolytic and cellulolytic enzymes (Lyford et al. 1967).

In general, it appears that the primary effect of tannins is on protein digestibility and not on the digestibility crude fibre, nitrogen-free extract, or ether extract. In view of the highly deleterious role of condensed tannins, Lohan et al. (1983) partitioned the total tannins into condensed and hydrolyzable forms. Tree fodders free of condensed tannins appear to be used better than those with condensed tannins. The crude fibre digestibility of tree fodders free of condensed tannins ranged from 63 to 79%; in tree fodders containing a high level of condensed tannins (*E. jambolana*, 3.23%; *T. bellirica*, 5.20%), the digestibilities were 1 and 10%, respectively. Moderate intakes of tree fodders containing tannins do not seem to affect palatability or digestibility of nutrients, except for a slight decrease in crude protein intake.

Extensive studies are needed to determine condensed and hydrolyzable proportions of tannins in important tannin-containing tree fodders. Levels of tolerance to tannins by livestock and the effects of tannins on microbes in the rumen should also be investigated.

Government policy

The National Commission on Agriculture (NCA 1976) received a communication from the Government of India recommending that the Indian

Veterinary Research Institute, National Dairy Research Institute, and agricultural universities undertake studies on the nutritive value of tree fodders, realizing the importance of farm forestry and social forestry in rural development programs. The World Bank is prepared to finance such social forestry projects.

Together with changes in livestock populations, there is also the changing lifestyles of the human population and the agronomic practices in different agroclimatic zones. Under these circumstances, the proliferation and use of fodder trees and forages have to be controlled so as not to disturb the ecological balance. The economic benefits of fodder trees can then be realized through livestock. Observing the ecological degradation, the Government of India has made it a policy to reverse the ecological degradation by way of afforestation. *Vanamohotsava*, for example, is an annual celebration in July that focuses on intensive tree planting. Specifically, multipurpose species are planted to provide the basic "five F's" (fuel, fodder, fibre, fruit, and fertilizer). The existing programs in social forestry envisage augmentation of village income by producing fuel, fodder, food, fibre, fertilizer, and forest products for plant-based industries (oil, rubber, etc.). This new policy aims at the rehabilitation of land resources for future use and the reduction of pressure on the reserve forest.

How to increase top feed use and efficiency

An integrated approach for the restoration and benefit of the community needs to be adopted for temperate, tropical, and semi-arid fodder trees. Attention must be focused on the following aspects while formulating government policies for various integrated systems:

- Promising trees and shrubs for introduction into the various climatic zones of India must be identified, with simultaneous development of easy and quick methods of raising suggested fodder trees under various integrated systems.
- A rational proportion of tree and shrub cover in grazing lands needs to be developed.
- An efficient marketing network is needed to accelerate the judicious use and to set proper prices for minor products.
- The two-tier concept, providing forage to the animal population and increasing the carrying capacity of the grazing lands, must be promoted. The heterogeneity ensures better use of environmental resources as the biomorphs are of different heights and their roots extend to different depths.
- A diversified or multitiered silvipasture system, that will ensure better use of solar energy, capture efficiency, and energy flow to the food chain, should be developed.
- People's involvement for proper restoration of fodder trees should be sought while afforesting community lands.
- The *Van Panchayats* (community tree plantations in villages) need to be administered by a single department and a village committee should decide on the areas to be used, the species to be planted, and on the protection and

maturity of plants. Enough fodder should be available within a 7 km walking distance.

- There should be a complete ban on the industrial use of fodder trees.
- The principle of shrubs and fodder tree management should sustain supplies of fodders together with rest periods to ensure recovery from any damage caused by partial defoliation.
- Lopping management varies from species to species depending on their growth capacity after lopping, their active growing period, their period of leaf fall, etc. However, the following guidelines can be kept in mind about their management: fresh leaves should not be lopped as they are often toxic; saplings and poles should not be lopped; about two seasons' rest is required after lopping for recovery; lopping may be restricted to the lower two-thirds of the crown, the upper one-third can produce the feed; at the time of lopping, branches having a diameter of over 7.5 cm should be avoided; and lopping should be avoided as much as possible on eroded areas or on areas prone to erosion.
- The incorporation rate of tree leaves and pods into the diets of different livestock, without loss of animal performance, should be determined.
- Large-scale production of complete pelleted feeds for sheep and goats should be attempted by incorporating different tree leaves and pods that have fallen to the ground.
- The chemical composition of leaves and pods, nutritive values, and toxic factors and the methods to remove them need to be studied.
- The economic feasibility of incorporating fodder leaves and pods into livestock diets needs to be determined.

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