Fodder trees and fodder shrubs in range and farming systems of the Asian and Pacific region

by C.P. Chen, R.A. Halim and F.Y. Chin

INTRODUCTION

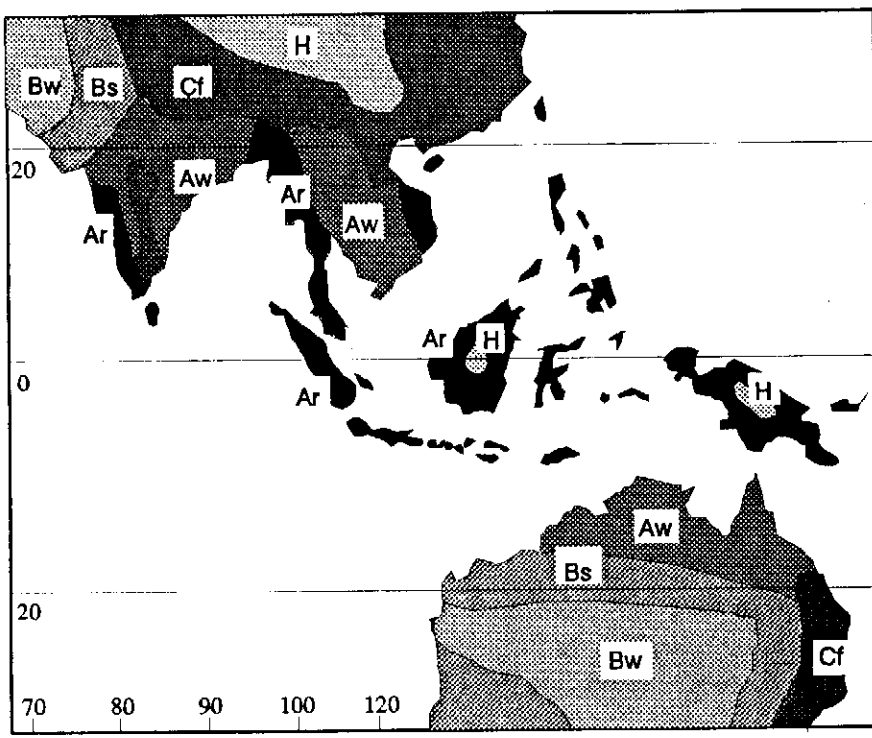
The Asia and Pacific region encompasses a wide range of climatic conditions and a diversity of socio-cultural entities. This diversity has given rise to various farming systems, each of which aims at optimizing the utilization of the natural resources they are endowed with. The multitude of agro-climatic zones confers upon the region a vast assemblage of tree and shrub species which could potentially benefit livestock production. Despite the variability in farming systems there are some features which are common across the region. Farms sizes are generally small (1-2 ha) and some farmers may not own any land but have access to communal lands. Where soils and climate are amenable to cropping, food and commercial crop production takes precedence over livestock, especially in heavily populated areas. This paper discusses the various farming systems and the extent to which tree and shrub fodders have been incorporated into the system as feed resources for livestock. The list of species, the plant characteristics and the agronomic features will be discussed.

TREE FODDERS WITHIN CLIMATIC ZONES

According to the classification of Trewartha (1954), there are five climatic groups in the Asia-Pacific environment (Figure 1). These include:

(a) Tropical wet (rainforest)
(b) Tropical wet and dry (savannah)
(c) Semi-arid or steppe,
(d) Arid or desert
(e) Subtropical humid

FIGURE 1. **Classification of climatic environments in the Asia and Pacific region (Trewartha, 1954).**



Ar - Tropical humid (rainforest)

Aw - Tropical wet and dry (savannah)

Bs - Semi-arid or steppe

Bw - Arid or desert

Cf - Subtropical humid

H - Undifferentiated highlands

TROPICAL WET (RAINFOREST)

Most of the arable land has been utilized for high-value food and industrial crop production. Ruminant livestock production in these areas plays a complementary role in utilizing by-products of crops and bringing in some income from land unsuited to crop production. Where population pressure is relatively light, as in Malaysia and New Guinea, traditional farming systems have not exploited the ample feed resources made available by evergreen shrubs and trees (Wong, 1990). Some feeding of leaves of fruit trees such as *Atrocarpus*, bananas and cassava leaves to goats is commonly practised but this has been based on the observation that goats have a natural preference for a mixed diet. The use of fodder shrubs such as *Leucaena* has been a recent phenomenon and much needs to be done to encourage small farmers to exploit this valuable feed resource. Many potentially useful fodder shrub species such as *Gliricidia*, *Flemingia*, *Tephrosia* and *Albizia* are grown in cocoa plantations as shade trees. Despite the fact that pruning of the shade trees is routinely practised, they have seldom been exploited for their feed value.

The use of fodder shrubs and trees has been more widely practised in Java where population pressure on land makes it imperative that every available feed resource is fully utilized. It has been a traditional practice in many parts of West Java to use fodder shrubs and trees as protein supplements fed with a basal feed of rice straw (Rangkuti *et al.*, 1990). *Leucaena* and *Sesbania grandiflora* are fed to Bali cattle at a rate as high as 15-20 kg/head daily.

In the Philippines, species such as *Leucaena* have been traditionally used in ruminant livestock production although the use of other species is rather new (Trung, 1990). *Leucaena* is not regarded solely as a ruminant feed and its use includes that as a source of fuel, reforestation and erosion control, shade and as fertilizer in agroforestry. Feed mills in the Philippines have established buying stations for dried *Leucaena* leaves in the villages, but this industry has been hard hit by psyllid infestation in the late 1980's.

TROPICAL WET AND DRY (SAVANNAH)

For regions experiencing a monsoonal climate such as central Thailand and a major part of the Indian sub-continent, fodder shrubs and trees may be the only available living feed resource during the dry season when shallow-rooted grasses and herbs die off. Thus in Thailand, which experiences 3 months of dry season, drought-resistant fodder shrub species such as *Leucaena* provide valuable energy and protein sources for ruminants (Wanapat, 1990). In addition, leaves of fodder shrubs which grow well in the wet season, such as cassava, pigeon pea and pseudostems of bananas, are harvested and dried for storage to be fed later with rice straw during the dry season. Bangladesh, which has a similar monsoonal climate, has the added population pressure on limited land for fodder production. Arable land is used fully for food and cash crops. In this situation shrubs and tree fodders are planted on bunds, riversides, waysides and homesteads (Saadullah, 1990). The major ruminant feed is straw and the use of leguminous fodder shrubs supplements the protein needs of the animal.

SEMI-ARID

The semi-arid climate in many parts of India and the pressure on land use have made tree and shrub fodders a more important component of feeds for ruminants compared to grasses or grass-legume pastures. Dry, deciduous vegetation is mostly found in semi-arid regions and is confined to the north-west area of the subcontinent. Many of the fodder trees are not cultivated and the landless population which owns small herds of sheep and goats depends on shrubs and tree feed resources growing near the villages, roadsides and community lands (Raghavan, 1990). When the sources in the vicinity of villages are depleted the rural women frequently reserve forest areas in the hills to obtain the daily requirements of their livestock. 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 feed is scarce. Although most of the trees and shrubs used for animal feed are not cultivated, there are traditional farming systems in India where they are deliberately planted by farmers

in an agrosilvicultural system. Trees are planted with crops to provide sources of fuel and feed. In Pakistan, which has a semi-arid climate, trees play a dominant role in livestock feeding and in providing fuel. A system of alternate husbandry has become established in some areas of Sind, where *Acacia* is the main cultivated genus (Akram *et al.*, 1990). *Acacia* is mainly used for fuel but its leaves and pods are used for fodder when other types of fodder are in short supply. *Acacia* is cultivated in rows 10-12m apart and the land in between is used for cropping until the trees mature.

MONTANE REGIONS

The mountainous terrain in parts of Asia, such as in the northern Indian sub-continent, provides a different set of constraints to ruminant livestock production. In Nepal, most of the fodder trees and shrubs are found in the hill regions (800-2000m), where over 98 species are found to grow naturally. When farmers migrated to the *Terai* (plains) region many brought with them some propagatory materials which they planted around their farms and on marginal lands, terraced banks and forests (Joshi and Singh, 1990). Shrubs and tree fodders are used as fresh green feed to livestock as well as a source of fuelwood.

SUBTROPICAL HUMID

In the sub-tropical humid climate that is found in southern China, there is a great diversity of tree and shrub fodders that are traditionally utilized by ruminant livestock farmers. More than 400 species of trees and shrubs are cultivated, widely distributed and used by farm animals (Xu, 1990). The tree fodders are divided into three classes: needle leaves (pine), broad leaves and shrubs. Pine needles are used in the industrial production of animal feed for pigs and poultry. Similarly, broad-leaf fodders such as poplar (*Populus*), willow (*Salix*), elm (*Ulmus*), and locust (*Robinia*) are made into leaf meal for monogastric feeding. Shrubs are mainly used by grazing animals especially goats. They are an important component of feed for the grassland areas in northern and western China, covering over 220 million ha with 100 million goats and sheep. In

southern China, grazing districts are in the mountainous areas with 46 million ha of tropical and subtropical grasslands. The warm and wet climate favours tree and shrub growth where they provide a substantial portion of the feed for the 26 million goats and 10 million sheep.

There are more than 200 of such known multipurpose tree species which are fixing nitrogen and useful as fodder. Nearly all of these species are tropical or subtropical. Details of some of the 25 species on their origin, distribution, uses, description and forage value are summarised by Brewbaker (1986). Lately, a compendium list of more diversified tree and shrub species which includes 74 genera comprising 269 species, was compiled by Blair (1990). Details of some *Tamarindus*, *Prosopis*, *Acacia* and *Pterocarpus* species used for fruit, forage and timber are described by NAS (1979).

There are 13 shrub and tree fodders being widely used and incorporated into ruminant feeding systems by the Asian farmers (Devendra, 1990). Those species are *Acacia* (*A. catechu*, *A. nilotica*, *A. sieberiana*), *Manihot esculenta*, *Calliandra calothyrus*, *Erythrina variegata*, *Ficus* (*F. exasperata*, *F. bengalnensis*, *F. religiosa*), *Gliricidia*, *Artocarpus heterophyllus*, *Albizia lebbeck*, *Leucaena*, *Prosopis* (*P. juliflora*, *P. glandulosa*), *Cajanus cajan*, *Sesbania* (*S. grandiflora*, *S. sesban*) and *Tamarindus indica*. *Cajanus cajan* is the species receiving intensive research as a grain crop (Nene, 1981). In the arid and semi-arid environment, such as in northern parts of Pakistan, India and China, species seem to have great potential for fodder and wood production but with slow establishment and growth. Whilst in the wet climate, vigorous growing species, such as *Leucaena*, *Gliricidia*, *Sesbania*, *Erythrina* and *Cassava* are most popular leaf materials. However, *Gliricidia* tends to shed its leaves during the dry season, whereas the *Leucaena* receives severe attack from psyllids.

SPECIES CHARACTERISTICS AND AGRONOMY

The ideal multipurpose tree species, should be able to fulfil the six-"F"s basic objectives of fodder, fuel, fruit/food, fibre, forest and fertilizer (green manure) (Raghavan, 1990). The desirable agronomic characteris-

tics of fodder trees are:
(1) ease of establishment,
(2) good competitive ability,
(3) high productivity and persistence under repeated cutting or grazing,
(4) ability to adapt to Asian and Pacific climatic edaphic conditions,
(5) require no fertilizer (low input system),
(6) resistant to local pests and diseases,
(7) ability to produce seed or be reliable for vegetative propagation, and
(8) have good nutritive value and reasonable palatability to animals (Ivory, 1990).

Generally, adverse soil conditions are prevalent in Asia and Pacific areas. For instance, of the soils in Southeast Asia and in South Pacific Islands, 51% of the total area are utisols and 44.6% combisols (ochrepts/tropepts) respectively (Blair *et al.*, 1986). Soils in the tropical and subtropical climatic zones are always associated with low mineral content such as N, P, S, K, Ca, Mg, Cu, Mo and B (Kerridge *et al.*, 1986) and high aluminium saturation which are restrictive to root growth.

In assessing species, it is essential to consider the plant agronomic features in relation to the desirable objectives and the soil and climatic factors. For instance, Hill (1971) reported that *Leucaena* grows best in alkaline, calcareous, clayey soil and obtains poor growth on acid soils which are saturated with aluminium and manganese. Similar responses were observed in a solution culture that all *Leucaena* cultivars reacted to level of pH ranging from 3.5 to 6.0 and that the cultivars were severely affected by aluminium concentration at 8 ppm (Wong and Devendra, 1983).

Tree and shrub fodders usually sustain a long life-cycle, except for a few fast growing ones. This presents difficulties in multiplication through seed which faces severe competition from other weeds due to the slow plant establishment. Raising seedlings in the nursery may be beneficial especially for the small farmer, in trying to rapidly establish home plot fodder. For range farming, direct seeding in strips or rows is advisable. Sometimes it may be a problem to get sufficient seed from species like *Gliricidia* so that vegetative propagation may have to be

employed.

One agronomic practice which affects fodder yield is tree plant density. Generally, the higher the tree density, the higher the total plant yield but individual tree yield decreases. Also, higher tree densities reduce weed competition. There is great variation in optimum plant density ranging from 1-15 trees/m^2 for optimum yield. Ivory (1990) reported that, under a cut and carry system, highest leaf and wood yield of *Leucaena*, *Gliricidia*, *Sesbania* and *Calliandra* were recorded at 4 trees/m^2, but this was dependent upon good rainfall. In less humid environments, a lower yield is expected. Other influential agronomic factors that affect tree and shrub fodder yields are the cutting intensity and frequency. Longer cutting intervals and less intensive cutting generally increase plant biomass. In the case of *Leucaena*, high forage yields are obtainable at a cutting height of between 1-3m and at a frequency between 60-90 days (Table 1). However, the edible material of tree fodders may vary greatly when leaf and wood fractions are taken into account. A range of *Leucaena* leaf fraction of between 31% cut at 120 days to 71% cut at 30 days was reported (Ferraris, 1979; Topark-Ngarm, 1983).

It has been generally recommended that the supplement of fodder tree leaves should be less than 30% of the diet and for some species it should not exceed 15% of the total feed intake. Such a limitation is usually due to the plant toxins or secondary compounds which inhibit the digestibility and reduce the acceptability to animals. Phenolics are the most widespread secondary compounds in almost all the woody species. It occurs at 10-20% of leaf dry weight in the tropical shrubs. A wide range of *in vitro* dry matter digestibility (IVDMD) from 16.9 to 66.9 was reported (Vercoe, 1987). The mean IVDMD of 12 tree fodders ranged 36%-63% for leaf and 34.5-58.2% for edible stem, whereas the crude protein was 11.3-30.6% leaf and 9.4-18.1% edible stem.

TABLE 1.
Cutting height and cutting frequency effects upon yield of *Leucaena*

Cutting Height (cm)	Cutting interval (days)	Yield (t/ha/year)	Reference
100	(40)	113.0 FW total	Siregar (1983)
150	(60)	28.7 FW total	Castillo *et al.* (1979)
90	90	12.5 DW total	Ozman (1981a,b)
50*	30	14.6 DW total	Perez & Melendez (1980)
150*	70*	39.4 FW total	Krishnamurthy & Munu Gowda (1982a,b)
150*	70*	28.0 FW total	
5*	(120)	50.6 FW total	Takahashi & Rippeton (1949)
(5)	110*	13.0 DW leaf	Guevarra *et al.* (1978)
30*	40	5.4 DW leaf	Pathak *et al.* (1983)
120*	(30)	4.0 DW leaf	Isarasanee *et al.* (1985)
(100)	85	-	Samali *et al.* (1983)
(30)	30/60/90$^{n.s.}$	8.2 DW leaf	Savory & Been (1979)
(10)	120*	9.0 DW leaf	Ferraris (1979)
30-90$^{n.s.}$	42-84$^{n.s.}$	15.2 DW leaf	Evensen (1984)
75	70	14.2 DW leaf	Topark-Ngarm (1983)

( ) only height/frequency used
* maximum height or longest frequency used
$^{n.s.}$ no significant differences
Source: Adopted from Horne *et al.* (1986)

Blair (1990) reported that the nitrogen value of 8 tree legumes at or above 1.8% level, would be sufficient for the growth of 300-500 kg cattle. More detail information on forage quality and chemical composition of fodder trees was presented by Brewbaker (1986). However, information from Vercoe (1987) on 23 tree species indicated that the level of phosphorus (0.05-0.18%) was the most deficient, as well as the low concentration or marginal level of Na, Cu, Zn and potential deficient mineral of Co, Se and Mo.

INCORPORATION OF FODDER SHRUBS AND TREES INTO FARMING SYSTEMS

The competitive land use between crops and livestock exerts considerable pressure against utilization of arable land for planting fodders and pastures. In this situation, a number of approaches have been suggested in order to incorporate fodder shrubs and trees without competing with crops. This has been discussed previously (Topark-Ngarm, 1990) and a summary of these approaches is presented. Four ways in which fodder shrubs and trees can be incorporated are:

1. Planting a living fence around the household

Fodder shrubs such as *Leucaena leucocephala*, *Pithecellobium dulca*, *Gliricidia sepium*, *Sesbania grandiflora* and *Artocarpus heterophyllus* can be grown as living fences which provide not only human food and fuelwood but also animal feed. Experience in Thailand shows that the fence can be established by direct seeding or transplanted seedlings at close spacing and be ready for use in 6-8 months. *Gliricidia sepium* has been extensively used in Indonesia and the Philippines and is easily established by sticking the stem or branch cuttings into the ground.

2. Vegetation on uncropped lands

In many of even the most intensively cropped areas of the region there are pockets of land which cannot be used for cropping. These may be in the form of farm boundaries, paddy bunds or forest margins which could be used to grow some shrubs and trees. These areas could be

planted with fodder shrubs and trees to augment protein needs of livestock and integrated with plantation agriculture.

3. Hedgerows in alley cropping

A specific concept in incorporating fodder shrubs and trees into farming systems producing annual crops has been developed by the International Institute of Tropical Agriculture (IITA). Shrubs and fodder trees are grown as hedgerows in cropped land. These serve as windbreaks or heatbreaks and provide green manure fertilizer for the crops. During the productive period, the cut material from the hedgerow species often provides fodder in excess of the amount needed from green manure for animals. Shade trees such as *Gliricidia*, used in cocoa plantations, can be treated the same way when they are routinely pruned to prevent overshading.

4. Component species in inter-cropping

In this system, shrubs or fodder trees are grown in alternate rows or rows adjacent to food crops. Trees are pruned once or twice for fodder or to reduce competition and shading during the growing period of the crops. Species used in this system are limited to fast growing ones and those tolerant to frequent cuttings. Examples of these include small shrub legumes like *Stylosanthes scabra*, *Stylosanthes viscosa*, *Cajanus cajan* and *Desmanthus virgatus*.

CONCLUSION

It is evident that the Asian and Pacific region is richly endowed with a diversity of fodder shrubs and tree species that can serve as useful feed resources. At present, most of the trees and shrubs used in farming systems comprise those that grow naturally in the forest and in uncropped marginal lands. Sufficient evidence from research has shown that improved animal production can be obtained by incorporating shrub and tree fodders as protein supplements. The fact that the planting of fodder shrubs and trees has not been more widely adopted by farmers in the region may have been caused by a lack of information on the economics

of production and the long term benefits to the overall farming systems. While substantial work has been conducted on yield and nutritive value of fodder trees, very little work has been reported using a "systems approach" to study the interacting factors that impinge on a farming system which incorporate fodder shrubs and trees. Package technologies that incorporate fodder shrubs and trees without imposing competition on crops must be formulated in order for it to be more widely adopted.

Bibliography

Akram, M., Hanjra, S.A., Qazi, M.A. and Bhatti, J.A. 1990. Availablity and use of shrubs and tree fodders in Pakistan. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals.* Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989. IDRC-276e, Ottawa, Ontario, pp. 176-182.

Blair, G.J., Orchard, P.W. and Mc Caskill, M. 1986. Soil and climatic constraints to foliage defoliation. In: G.J. Blair *et al.*, *Forages in Southeast Asian and South Pacific Agriculture.* CIAR Proceedings No. 12, A.C.T., Canberra, Australia, pp. 29- 35.

Blair, G.J. 1990. The diversity and potential value of shrubs and tree fodders. In: C. Devendra (ed.), *Shrubs and tree fodders for farm animals.* Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989. IDRC-276e, Ottawa, Ontario, pp. 2-11.

Brewbaker, J.L. 1986. Leguminous trees and shrubs for southeast Asia and the South Pacific. In: G.J. Blair *et al.*, *Forages in Southeast Asian and South Pacific Agriculture.* CIAR Proceedings No. 12, A.C.T., Canberra, Australia, pp. 43-50.

Devendra, C. 1990. The use of shrubs and tree fodders by ruminants. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals.* Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989. IDRC-276e, Ottawa, Ontario, pp.42-60.

Ferraris, R. 1979. Productivity of *Leucaena leucocephala* in the wet tropics of north Queensland. *Tropical Grassland* 13(1): 20-27.

Hill, G.D. 1971. *Leucaena leucocephala* for pasture in the tropics. *Herbage Abstracts* 41: 111-119.

Horne, P.M., Catchpoole, D.W. and Ella, A. 1986. Cutting management of tree and shrub legumes. In: G.J. Blair *et al.*, *Forages in Southeast Asian and South Pacific Agriculture.* CIAR Proceedings No. 12, A.C.T., Canberra, Australia, pp. 146-169.

Ivory, D.A. 1990. Major characteris-

tics, agronomic features and nutritional value of shrubs and tree fodders for farm animals. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals.* Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989. IDRC-276e, Ottawa, Ontario, 22-38.

Joshi, N.P. and Singh, S.B. 1990. Availability and use of shrubs and tree fodders in Nepal. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals.* Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989. IDRC-276e, Ottawa, Ontario, pp. 211-220.

Kerridge, P.C., Edwards, D.G. and Sale, P.W.G. 1986. Soil fertility constraints - Amelioration and plant adaptation. In: G.J. Blair *et al.*, *Forages in Southeast Asian and South Pacific Agriculture.* CIAR Proceedings No. 12, A.C.T., Canberra, Australia, pp. 179-187.

NAS (National Academy of Science). 1979. *Tropical legumes: resource for the future.* NAS, Washington D.C., USA.

Nene, Y.L. 1981. *Proceedings of the International Workshop on Pigeonpeas.* ICRISAT, Hyderabad, India. 15-19 December 1980. Patancheru, A.P. India. 451pp.

Raghavan, G.V. 1990. Availability and use of shrubs and tree fodder in India. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals.* Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989. IDRC-276e, Ottawa, Ontario, pp. 196-210.

Rangkuti, M., Siregar, M.E. and Roesyat, A. 1990. Availability and use of shrubs and tree fodders in Indonesia. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals.* Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989. IDRC-276e, Ottawa, Ontario, pp. 266-278.

Saadullah, M. 1990. Availability and use of shrubs and tree fodder in Bangladesh. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals.* Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989. IDRC-276e, Ottawa, Ontario, pp. 221-236.

Topark-Ngarm, A. 1983. Testing shrub legumes for forages crops in northeast Thailand. *Leucaena Research Report* 4: 71-78.

Topark-Ngarm, A. 1990. Shrubs and tree fodders in farming systems of Asia. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm*

animals. Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989. IDRC-276e, Ottawa, Ontario, pp. 12-21.

Trewartha, G.T. 1954. *An introduction to climate*. McGraw-Hill, New York.

Trung, L.T. 1990. Availability and use of shrubs and tree fodders in the Philippines. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals*. Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989. IDRC-276e, Ottawa, Ontario, pp. 279-294.

Vercoe, T.K. 1987. Australian Acacia in development countries. In: Turbull, J.W. (ed.), *Fodder potential of selected Australian tree species*. ACIAR Proceedings No. 16. ACIAR, Canberra, Australia, pp. 95-100.

Wanapat, M. 1990. Availability and use of shrubs and tree fodders in Thailand. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals*. Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989. IDRC-276e, Ottawa, Ontario, pp. 244-254.

Wong, C.C. 1990. Availability and use of shrubs and tree fodder in Malaysia. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals*. Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989. IDRC-276e, Ottawa, Ontario, pp. 255-265.

Wong, C.C. and Devendra, C. 1983. Research on leucaena forage production in Malaysia. In: *Leucaena Research in the Asian-Pacific Region*. Proceedings of a workshop held in Singapore, 23-26 November 1982 IDRC, Ottawa, Ontario, pp. 55-56.

Xu Zaichun 1990. Availability and use of shrubs and tree fodders in China. In: Devendra, C. (ed.), *Shrubs and tree fodders for farm animals*. Proceedings of a workshop in Denpasar, Indonesia, 24-29 July 1989. IDRC-276e, Ottawa, Ontario, pp. 295-302.