SISTEMAS AGROFLORESTAIS

(AGROFORESTRY SYSTEMS)

MULTIPURPOSE LEGUMINOUS TREES AND SHRUBS FOR AGROFORESTRY

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ABSTRACT - An overview of the various agroforestry systems and practices that exist around the tropics and subtropics indicates that there are various ways in which farmers deliberately incorporate trees and shrubs on farm production fields. Many of the species so incorporated are legumes.

The role of woody perennials in agroforestry systems can be productive and/or protective. The former includes the production of food, fodder, fuelwood, mulch, green manure, wood and various other useful products. The most important protective functions entail the use of woody perennials for soil protection and conservation, and for enhancement of soil's productivity on a sustainable basis, especially on account of the nitrogen--fixing capacity of the vast majority of them.

Legumes are not the only group of woody species that have potential role in agroforestry, but they offer by far the maximum range of choice of woody species for agroforestry in terms of their economic uses as well as ecological adaptability. In addition to the several leguminous woody species that are well known in agroforestry, there are many whose potentials have hitherto not been fully understood. An evaluation of the agroforestry potentials of a few leguminous species from the point of view of their growth characteristics, ecological adaptability, combining ability with other species and uses/ functions is presented.

The science of agroforestry is still in its infancy. There is yet nobody of knowledge on the various management aspects of these potentially promising group of plants based on systematic research. However, some trials have recently been initiated in several places around the world. ICRAF, in its capacity as an international research council with a global mandate to catalyze and promote research in agroforestry, has assembled several multipurpose leguminous trees and shrubs of agroforestry potential at the Council's recently--established Field Station in Machakos, Kenya, primarly for demonstration and training purposes.

Index terms: N_2 fixation.

LEGUMINOSAS ARBÓREAS E ARBUSTIVAS DE MÚLTIPLOS USOS EM SISTEMAS AGROFLORESTAIS

RESUMO - Uma visão geral dos vários sistemas e práticas agroflorestais, que existem nas áreas tropicais e subtropicais, indica que há várias maneiras pelas quais os fazendeiros deliberadamente incorporam árvores e arbustos no sistema de produção agrícola, e muitas das espécies usadas são leguminosas.

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O papel das espécies lenhosas nos sistemas agroflorestais pode ser de produção e/ou de proteção. O primeiro inclui produção de alimento, forragem, lenha, cobertura morta, adubo verde, madeira e vários outros produtos úteis. A mais importante das funções protetoras é na conservação do solo e, também, no aumento da produtividade do solo, tendo em conta a capacidade de fixação de N_2 da vasta maioria das espécies.

As leguminosas não são as únicas espécies lenhosas com potencialidades nos sistemas agroflorestais, mas elas oferecem as mais amplas possibilidades de escolha em termos de seus usos econômicos, bem como a adaptação ecológica. Além das diversas espécies já conhecidas e usadas, existem muitas outras cujas potencialidades de uso em sistemas agroflorestais ainda não foram estudadas. Uma avaliação do potencial de uso agroflorestal de algumas espécies de leguminosas é apresentada neste trabalho, principalmente em termos das características de crescimento, adaptação ecológica, capacidade de crescimento em associação com outras espécies, bem como seus usos e funções.

O sistema agroflorestal é um campo de pesquisa ainda incipiente. Não há ainda informações advindas de pesquisa sistematizada sobre os vários aspectos de manejo dos grupos potencialmente promissores. Entretanto, alguns experimentos foram recentemente iniciados em diversas localidades ao redor do mundo. O ICRAF, na qualidade de conselho internacional, tem catalizado e promovido a pesquisa sobre os sistemas agroflorestais e reuniu, no recentemente criado campo experimental de Machakos, no Quênia, um banco de árvores e arbustos de uso potencial nos sistemas agroflorestais, com a finalidade primordial de demonstração e treinamento.

Termos para indexação: fixação de N_2.

INTRODUCTION

Agroforestry has generated rather unparalleled levels of enthusiasm in recent years among researchers, development experts, and policy planners of tropical land use systems. This euphoria about the agroforestry concept has even led to a false belief - at least in some quarters - that agroforestry is a completely new practice and even a panacea for all the defects and shortcomings of land management in the tropics. Although it is true that the scientific principles of agroforestry are only now being examined and hence understood, the practice, in some form or other, has been in existence since very early times, especially among farmers in warmer parts of the world. But these practices had hitherto been bypassed, if not neglected, by researchers and other experts and consequently have not been a part of the resource-rich farming. However, agroforestry and other integrated approaches to land use have now come to the limelight in the wake of the increasing population pressure, consequent destruction and mismanagement of forests by man in his quest for food and wood products, and the resultant environmental problems. Increasing dependance of modern agricultural technology on high-value inputs on the one hand, and the deteriorating economic situation of most of the developing countries on the other have caused a renewed awareness about the productive and protective value of trees, and the realization of the potentials of age-old conservation farming technologies. Consequently, efforts are now being made to devise the most appropriate ways to integrate the production of trees and other woody species with the production of agricultural crops and/or livestock simultaneously from the same piece of land in a sustainable manner.

AGROFORESTRY

In spite of the tremendous amount of interest on agroforestry, quite a bit of confusion and ambiguity prevails as to "what is agroforestry". Various definitions have been suggested for agroforestry (see Agroforestry Systems, Vol. 1, pp.7-12, 1982). However, as opined by Nair (1983a), it is generally agreed that agroforestry represents an approach to integrated land use involving deliberate mixture or retention of trees and other woody perennials in the crop/animal production fields. Thus, it combines elements of agriculture, whether crops or animals, with elements of forestry in sustainable production pattern on the same piece of land, either simultaneously or sequentially. The objective of most agroforestry systems is to optimize the beneficial effects of interaction of the woody components with the crop and/or animal components to obtain a production pattern that, in terms of total quantity, diversity of end-products, or sustainability, is preferable to what is usually obtained from the same resources under prevailing social, ecological and economic conditions (Lundgren 1982).

The important role of agroforestry in the fragile or marginal environments has rightly been recognized (King 1979, Chandler & Spurgeon 1980) as one of its most significant potentials. The potential role of trees as components of more productive and sustainable land use systems for such environments may particularly be relevant to consider where rainfall is low and soil dessication is high, or where rapid leaching of soil nutrients degrades agricultural systems to a low level equilibrium once the natural forest vegetation is removed (Lundgren & Nair 1983). However, by saying this, the intention or implication is not to ignore or belittle the importance and feasibility of agroforestry in high-potential lands. Indeed, we may look for and expect to find indigenous agroforestry systems wherever there has been a history of population pressure and a long-standing need for efficient management of scarce resources. Thus, on both marginal and high potential land, and at different levels of population pressure, diversified agroforestry systems may especially be appropriate wherever lack of rural infrastructure or unfavourable economic environments make it imperative for risk-reducing small farmers to produce most of their basic needs directly from the land resources at their disposal (Lundgren & Raintree 1983). Agroforestry has also a special role in combating deforestation and forest destruction because the primary reason for deforestation is man's ever-increasing quest for more and more land for producing the much-needed food, and agroforestry offers possibilities for producing the food without destroying the wood (King 1980).

AGROFORESTRY SYSTEMS AND LEGUMINOUS WOODY PERENNIALS

State-of-the-art

If we look at the existing land use systems keeping the broad concept of agroforestry as outlined earlier in mind, we find that several types of agroforestry systems abound around the world (Nair 1979, 1980, 1983b). The International Council for Research in Agroforestry (ICRAF) is currently undertaking a global inventory of such existing agroforestry systems and practices. Table 1, that was prepared as a basic document for the project, shows a preliminary overview of the situation in the developing countries, indicating the most prominent examples found in the different regions. Though based on the existing knowledge prior to the commencement of the formal survey phase of the project, the Table shows the diversity of agroforestry systems and practices. A generalized scheme for the classification of the major forms of agroforestry and very illustrative schematic patterns have been proposed by Torres (1983a) based on the dominant role of the woody component in each system. Without going into the details, suffice it to say that there are several ways in which farmers deliberately incorporate different types of

TABLE 1. Some examples of prominent agroforestry systems and practices in the developing countries.

Prominent systems	Systems and practices in different geographical regions					
	S.E. Asia	S. Asia	Mediterranean and middle east	Eastern, central and humid west Africa	Arid and semi-arid west Africa	American tropics
1. Agro-silviculture	1. Commercial trees among crops 2. Fruit/shade trees among crops 3. Live fences 4. Shelterbelts 5. Taungya 6. Shifting cultivation systems 7. Intercropping in plantation crops (rubber, oil palm, coconut)	1. Taungya 2. Plantation crops + arable crops 3. Commercial trees and fruit trees with crops 4. Live fences + shelterbelts 5. Various trees on farmlands for productive functions 6. Various forms of shifting cultivation 7. Medicinal plants + agri. species	1. Olive + cereals (on terraces, 'banquettes, 'cuvettes', etc.) 2. Poplars along irrigation canals 3. Trees for sand dune reclamation 4. 'Huertas' - small plots irrigated crops + fruit trees 5. Aromatic, medicinal and fruit trees with crops	1 Taungya 2. Cacao/food crops/forest complex 3. Plantation crops (oil palm/rubber) and root crops complex 4. Coffee + banana 5. Mixed perennial crops 6. Gum arabic + millet 7. Shifting cultivation/bush fallow systems	1. Use of trees on farmlands for protective role (windbreaks, dune fixation) 2. Productive + protective role of trees on farms (*A. albida/Leucaena* + agric. crop systems)	1. Trees in perennial cach crops (coffee, cacao, tea) 2. Trees for organic matter and mulch with annual crops 3. Tree live fences 4. Windbreaks and shelterbelts 5. Trees as support for climbing commercial crops 6. Taungya 7. Shifting cultivation systems
2. Silvo-pastoral	1. Pasture in forest plantation 2. Pasture in secondary forests 3. Commercial trees in pastures 4. Fruit/shade trees in pasture 5. Fodder trees 6. Coconuts + pasture	1. Pasture under trees 2. Plantation crops + cattle grazing 3. Fodder trees and shrubs 4. Fruit trees and commercial trees in pastures	1. Oak forest + grazing 2. Pig breeding and forestry 3. Range land improvement	1. Gum arabic + livestock 2. Plantation crops (coconut/cashew) + pasture	1. Nomadic/semi-nomadic/transhuman 2. Sedentary livestock grazing systems/ browsing systems 3. Fodder tree/shrub systems	1. Trees in pasture 2. Pasture in natural regeneration forest 3. Trees lopped for fodder 4. Trees used for browsing

TABLE 1. Continuation

Prominent systems	Systems and practices in different geographical regions					
	S.E. Asia	S. Asia	Mediterranean and middle east	Eastern, central and humid west Africa	Arid and semi-arid west Africa	American tropics
3. Agro-silvo-pastoral	1. Crops and grazing in plantations 2. Agri. tree crops + grazing in forest plantation 3. Multipurpose trees with crops/animals 4. Integrated farming systems with agric. plantation crops (rubber, coconut, oilpalm)	1. Plantation crops + arable crops + livestock 2. Agric. tree crops + grazing in forest	Range land management	1. Coconuts/other plantation crops + food crops + grazing 2. Coffee + banana + dairying 3. Horticultural complex systems 4. Plough culture complex systems	1. Forestry dominating (forest lands) 2. Agriculture dominating (crop lands) 3. Livestock dominating (crop lands)	1. Agric. plantation crops (coconut, rubber, fruit trees) with crops and pastures
4. Home gardens	Various forms of multispecies combination	1. Multistorey plant canopies in humid regions 2. Arid/semi-arid systems	Mainly in large cities	Various forms	Various forms	Various forms
5. Others	1. Silviculture in mangrove forests 2. Agri-silvi-fishery 3. Trees on bunds in fish breeding ponds 4. Swidden farming 5. Fuelwood agroforestry	1. Mixed perennial cropping 2. Irrigation systems 3. Various site-specific systems 4. Fuelwood systems	1. New system in Morocco (spice plantation for erosion control) 2. Apiculture + forestry 3. Fruit trees in deserts 4. Mushroom cultivation in forest	1. Pastoral systems with corral farming (highland/lowland interactive systems) 2. Mixed perennial cropping	1. Oasis 2. Irrigation systems 3. Various site-specific systems	Mixed perennial cropping

woody perennials in their crop/animal production fields. As an example, the results of Neunhaeuser (1983) can be cited: he and colleagues conducted a survey of land use systems in the smallholder farms of the semi-arid to sub-humid Machakos District in Kenya and identified several trees and shrubs that are used by farmers both on croplands and in the grazing land; a summary of their findings is given in Table 2. The Table shows that a good majority of the species so used are legumes. Another good example is the report of Okigibo (1977) on the use of indigenous trees and shrubs in the farming systems of West Africa.

There are also several other reports on the use of leguminous woody perennials in agroforestry systems around the world. Based on the literature survey conducted by ICRAF for the earlier-mentioned global inventory of agroforestry systems, some of the most prominent examples of leguminous and other nitrogen fixing woody perennials that are currently used in agroforestry systems in the tropics and subtropics are given in Table 3.

Role of leguminous woody perennials in agroforestry

In general, the role of woody perennials - including the leguminous ones - in agroforestry can be termed as productive and/or protective depending upon the dominant function(s) of such species.

Productive role

The productive role includes production of food, fodder, firewood and various other products from the woody perennials in agroforestry systems. One of the most promising technologies of this kind that is applicable in a wide range of situations is the hedgerow planting of appropriate woody species in crop production fields. The practice involves growing arable crops in the spaces or alleys between such hedgerows; the woody species is pruned periodically during the cropping season to prevent shading and to provide green manure to the arable crop. Promising results have been obtained from this type of studies conducted at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria (Wilson & Kang 1981), where the practice is called alley cropping. The most promising system based on those trials is *Leucaena leucocephala*/maize alley cropping. IITA studies showed that leucaena tops maintained maize grain yield at a reasonable level even with no nitrogen input on a low-fertility sandy Inceptisol, the nitrogen contribution by *Leucaena* mulch on maize grain yield being equivalent to about 100 kg/ha^{-1} for every 10 t/ha^{-1} of fresh prunings (Kang et al. 1981). The hedgerow cropping system offers the advantage of incorporating a woody species with arable farming system without impairing soil productivity and crop yields. The potential of nutrient (N) contribution by several candidate species of woody legumes suggests that a wide range of such species could be integrated into crop production systems. By adjusting the inter-row spacing of the woody species, mechanized equipments could be used, wherever deemed desirable, for various field operations connected with cropping. Moreover, the trees can be cut back and kept for various field operations connected with cropping. Moreover, the trees can be cut back and kept pruned during the cropping period and leaves and twigs applied to the soil as mulch and nutrient source, and bigger branches used as stakes or firewood. Research on these various aspects of hedgerow cropping system is in progress in various places around the world.

Integration of trees in crop production fields is an essential part of traditional farming systems in the dry regions also. Two typical examples are the extensive use of *Acacia albida* in the groundnut and millet producing areas of sub-Saharan Africa (Felker 1978) and the dominant role of *Prosopis cineraria* in the arid North-western parts of India (Mann & Saxena 1981).

The role of woody perennials on farmlands for producing fuelwood is another example of the

TABLE 2. Distribution of non-fruit trees according to frequency of occurrence on cropland and grazingland on smallholder farms in Machakos District, Kenya (Neunhaeuser 1983).

Tree species	t/s[1]	Number of households			
		cropland		grazingland	
		n.º	%	n.º	%
Terminalia brownii	t	25[2]	41[2]	36	59
Acacia tortilis[3]	t	15	25	39	64
Euphorbia tirucalli	t/s	10	16	-	-
Acacia mellifera	t	10	16	28	46
Lannea schweinfurthii	t	9	15	10	16
Lonchocarpus eriocaly	t	7	12	10	16
Rhus ternuinervis	t/s	6	10	11	18
Clerodendrum sp.	t	5	8	8	13
Albizia anthelminthica	t	4	6	5	8
Eucalyptus sp.	t	4	6	-	-
Balanites aegytica	t	3	5	12	20
Lannea rivae	t	3	5	7	12
Acacia nilotica	t	3	5	7	12
Grevillea robusta	t	3	5	-	-
Kigelia aethiopicum	t	3	5	3	5
Acacia etbaica	t	2	3	15	25
Commiphora africana	t	2	3	13	21
Acacia brevispica	t	2	3	12	20
Acacia senegal	t	2	3	5	8
Acacia robusta	t	2	3	3	5
Thespesia danis	t	2	3	2	3
Jacaranda sp.	t	2	3	-	-
Croton megalocarpus	t	1	2	10	16
Combretum zeyheri	t	1	2	7	12
Combretum apiculatum	t	1	2	5	8
Euphorbia candalabrum	t	1	2	4	6
Commiphora madagascariensis	t	1	2	3	5
Boscia angustifolia	t	1	2	2	3
Premna oligotricah	t	-	-	12	20
Pappea capensis	t	-	-	5	8
Grewia tembensis	t	-	-	4	6
Combretum molle	t	-	-	2	3
Cassia didymobotrya	t	-	-	2	3
Vanguera sp.	t	-	-	2	2
Lantana camara	t	-	-	1	2

[1] tree (t) or shrub (s)

[2] number of households and the percentage drawn from a total of 61 interviewed households

[3] data apply to *A. abyssiniea;* they both have the same vernacular name - Kilaa (Kamba language)

productive role of the species in agroforestry. The trees and shrubs that are incorporated on the farmlands in food production systems or for soil amelioration could also provide the much-needed fuelwood. Based on a study on the woodfuel supply from trees outside the forests in the highlands of Kenya, Gelder & Poulson (1982) emphasized the importance of agroforestry and identified several woody species that are suitable for the purpose. They calculated that a 2-ha farm, with a tenth of the area under woodlot, one hedgerow protecting the outer boundary and another one surrounding the homestead, and the "usual" spread of farm trees over the remaining area, could provide enough fuelwood to meet

Pesq. agropec. bras., Brasília, 19 s/n: 295-313, jun. 1984.

TABLE 3. Some leguminous woody perennials currently used in tropical/subtropical agroforestry.

Species	System/Practice	Major Eco-zone	Countries
Dalbergia sissoo	(SP)*Cut and carry fodder prod.	Tropical highlands	India, Nepal
Derris indica	(AS)*Multipurpose trees on farms	Arid/semi-arid	India
	(SP)*Cut and carry fodder prod.	Arid/semi-arid	India
Diphysa robinoides	(AS) Livefences/shelterbelts	Humid/sub-humid	Costa Rica
Enterolobium cyclocarpum	(SP) Shade/browse trees in pastures	Humid/sub-humid	Costa Rica
Erythrina abyssinica	(SP) Livefences/shelterbelts	Tropical highlands	Ethiopia
	(SP) Cut and carry fodder prod.	Tropical highlands	Ethiopia
	(ASP)*Crop/tree/livestock mix around homesteads	Tropical highlands	Ethiopia
Erythrina poeppigiana	(AS) Shade for commercial crops	Humid/sub-humid	Costa Rica
		Tropical highlands	Costa Rica
Gliricidia sepium	(AS) Shade for commercial crops	Humid/sub-humid	Brazil, Costa Rica, Philippines
	(AS) Livefences/shelterbelts	Humid/sub-humid	Costa Rica, Java
	(AS) Tree gardens	Humid/sub-humid	Java
	(SP) Cut and carry fodder prod.	Humid/sub-humid	Panama
	(ASP) Crop/tree/livestock mix around homesteads	Humid/sub-humid	Java
Inga edulis	(ASP) Crop/tree/livestock mix around homesteads	Humid/sub-humid	American tropics
Inga jinicuil	(AS) Shade for commercial crops	Humid/sub-humid	Mexico
Inga vera	(AS) Shade for commercial crops	Humid/sub-humid	Puerto Rico, West Indies
	(AS) Agroforestry fuelwood prod.	Humid/sub-humid	West Indies
Lespedeza bicolor	(AS) Multipurpose shrub on farmlands	Humid/sub-humid	Korea
	(AS) Agroforestry fuelwood prod.	Humid/sub-humid	Korea
	(SP) Cut and carry fodder prod.	Humid/sub-humid	Korea
Leucaena leucocephala	(AS) Shade for commercial crops	Humid/sub-humid	Nigeria, Papua N. Guinea
	(AS) Agroforestry fuelwood prod.	Humid/sub-humid	Philippines
	(AS) Hedgerow (alley) cropping	Humid/sub-humid	Nigeria
	(SP) Cut and carry fodder prod.	Humid/sub-humid	Philippines
	(ASP) Woody hedgerows for browse, mulch, green manure and soil conservation	Humid/sub-humid	Philippines
Leucaena esculenta	(AS) Shade for commercial crops	Humid/sub-humid	Mexico
Mimosa scabrella	(AS) Multipurpose trees on farmlands	Humid/sub-humid	Brazil
		Tropical highlands	Brazil
	(AS) Agroforestry fuelwood prod.	Humid/sub-humid	
		Tropical highlands	Brazil
Parkia biglobosa	(AS) Tree gardens - Multispecies Multipurpose associations	Humid/sub-humid	Central African Repub.
Acacia albida	(ASP) Crop/tree/livestock mix around homesteads	Arid/semi-arid	Ethiopia, Niger
	(AS) Agroforestry fuelwood prod.	Arid/semi-arid	Niger, Senegal
	(SP) Multipurpose fodder trees	Arid/semi-arid	Ethiopia, Senegal
Acacia auriculiformis	(AS) Agroforestry fuelwood prod.	Humid/sub-humid	Papua New Guinea
Acacia mearnsii	(AS) Agroforestry fuelwood prod.	Tropical highlands	Java, Kenya
	(AS) Multipurpose trees on farmlands	Tropical highlands	Java

TABLE 3. Continuation

Species	System/Practice	Major Eco-zone	Countries
Acacia senegal	(AS) Agroforestry fuelwood prod.	Arid/semi-arid	Sudan
	(SP) Multipurpose fodder trees	Arid/semi-arid	Kenya, Sudan
	(SP) Shade/browse trees in pastures	Arid/semi-arid	Kenya, Sudan
Acacia seyal	(AS) Agroforestry fuelwood prod.	Arid/semi-arid	Sudan, Upper Volta
	(SP) Multipurpose fodder trees	Arid/semi-arid	Kenya, Sudan
	(SP) Shade/browse trees in pastures	Arid/semi-arid	Senegal, Sudan
Acacia tortilis	(AS) Agroforestry fuelwood prod.	Arid/semi-arid	India, Kenya, Sudan
	(SP) Shade/browse trees in pastures	Arid/semi-arid	Kenya, Senegal, Sudan
	(SP) Multipurpose fodder trees	Arid/semi-arid	India, Kenya, Sudan
Albizia falcataria	(AS) Tree farms	Humid/sub-humid	Philippines
Albizia gummifera	(AS) Shade for commercial crops	Humid/sub-humid	Cameroun
Albizia lebbeck	(AS) Shade for commercial crops	Humid/sub-humid	India
		Tropical highlands	India
	(SP) Cut and carry fodder prod.	Humid/sub-humid	India
Albizia stipulata	(SP) Cut and carry fodder prod.	Tropical highlands	Nepal
Alnus acuminata	(AS) Shade for commercial crops	Tropical highlands	Brazil, Costa Rica
	(SP) Shade trees in pastures	Tropical highlands	American tropics
Andira inermis	(AS) Shade for commercial crops	Humid/sub-humid	Brazil, Costa Rica
Cajanus cajan	(AS) Multipurpose shrub on farmlands	Arid/semi-arid + Humid/ sub-humid	India
	(AS) Livefences/shelterbelts	Arid/semi-arid	India
	(AS) Agroforestry fuelwood prod.	Arid/semi-arid	India
Calliandra calothyrsus	(AS) Agroforestry fuelwood prod.	Humid/sub-humid	Java
	(AS) Multipurpose trees on farmlands	Humid/sub-humid	Java
	(ASP) Woody hedgerows for browse, mulch, green manure and soil conservation	Humid/sub-humid	Indonesia
	(SP) Cut and carry fodder prod.	Humid/sub-humid	Java
Cassia siamea	(AS) Tree gardens-multispecies Multipurpose species ass.	Humid/sub-humid	Cameroun
	(AS) Agroforestry fuelwood prod.	Humid/sub-humid, Arid/ semi-arid	Sudan
	(ASP) Crop/tree/livestock mix around homesteads	Humid/sub-humid	Nigeria
Ceratonia siliqua	(SP) Shade/browse trees in pastures	Arid/semi-arid	Middle East
Colophospermum mopane	(SP) Multipurpose fodder trees	Arid/semi-arid	Zambia, Zimbabwe
Parkia clappertoniana	(AS) Tree gardens Multispecies, multipurpose	Humid/sub-humid	Nigeria
Parkia speciosa	(AS) Tree gardens	Humid/sub-humid	Java

TABLE 3. Continuation

Species	System/Practice	Major Eco-zone	Countries
Pithecellobium dulce	(AS) Livefences/shelterbelts	Arid/semi-arid	Philippines
	(SP) Shade/browse trees in pastures	Arid/semi-arid	Hawaii
	(SP) Cut and carry fodder prod.	Arid/semi-arid	Philippines
Prosopis africana	(AS) Tree gardens - Multipurpose Mutispecies associations	Humid/sub-humid	Nigeria
Prosopis chilensis	(SP) Shade/browse trees in pastures	Arid/semi-arid	Bolivia, Chile, Peru
Prosopis cineraria	(AS) Multipurpose trees on farmlands	Arid/semi-arid	India
	(AS) Agroforestry fuelwood prod.	Arid/semi-arid	India
	(SP) Cut and carry fodder prod.	Arid/semi-arid	India
	(SP) Shade/browse trees in pastures	Arid/semi-arid	India
Prosopis juliflora	(AS) Agroforestry fuelwood prod.	Arid/semi-arid	Haiti
	(SP) Shade /browse trees in pastures	Arid/semi-arid	Middle East
Prosopis tamarugo	(AS) Agroforestry fuelwood prod.	Arid/semi-arid	Chile
	(SP) Shade/browse trees in pastures	Arid/semi-arid	Chile
Pterocarpus soyauxii	(AS) Tree gardens - Multipurpose Multispecies associations	Humid/semi,humid	Nigeria
	(ASP) Crop tree livestock mix around homesteads		Nigeria
Samanea saman	(SP) Shade/browse trees in pastures	Humid/sub-humid	American tropics
	(ASP) Tree/crop/livestock mix around homesteads	Humid/sub-humid	Nigeria
Sesbania bispinosa	(AS) Multipurpose trees on farmlands	Humid/sub-humid	India, Vietnam
	(AS) Agroforestry fuelwood prod.	Humid/sub-humid	North Pakistan
	(SP) Cut and carry fodder prod.	Humid/sub-humid + Arid/ semi-arid	India, Pakistan
	(ASP) Woody hedgerows for browse, mulch, green manure + soil conservation	Humid/sub-humid	India, Pakistan, Vietnam
Sesbania grandiflora	(AS) Livefences/shelterbelts	Humid/sub-humid	Java
	(AS) Tree gardens	Humid/sub-humid	Java
	(AS) Shade for commercial crops	Humid/sub-humid	Malaysia
	(SP) Shade/browse trees in pastures	Humid/sub-humid	Java
	(SP) Cut and carry fodder prod.	Humid/sub-humid	Java
	(ASP) Woody hedgerows for browse mulch, green manure + soil conservation	Humid/sub-humid	Java
	(ASP) Crop/tree/livestock mix around homesteads	Humid/sub-humid	Java
Tamarindus indica	(AS) Multipurpose trees on farmlands	Humid/sub-humid	India
Trema orientalis	(AS) Shade for commercial crops	Humis/sub-humid	Philippines
	(AS) Agroforestry fuelwood prod.	Humid/sub-humid + Tropical highlands	Java

* AS = Agrosilviculture; SP = Silvo-pastoral; ASP = Agro-silvo-pastoral

the fuel requirement of an average family. Several fast-growing firewood crops most of them legumes, suitable for different environmental conditions, have been identified (National Academy of Sciences 1980), and most of them combine well with conventional agricultural crops.

In the "animal agroforestry" systems, the woody component could be used either as a source of fodder to improve livestock productivity or to obtain another commodity such as fuel, fruit or timber. Based on this "productivity objective", silvopastoral systems can be grouped into browse grazing and forest/plantation grazing systems. The role of woody perennials in these systems has been reviewed excellently by Torres (1983b).

Protective role

The protective role of woody perennials in agroforestry stems from their soil improving and soil conserving functions. There are various avenues through which the leguminous woody perennials could improve and enrich soil conditions; these include fixation of atmospheric nitrogen, addition of organic matter through litterfall and dead and decaying roots, modification of soil porosity and infiltration rates leading to reduced erodibility of soil,and improving the efficiency of nutrient cycling within the soil--plant system (Nair 1983c). However, the main protective function of woody perennials is in physical conservation of the soil.

Tree planting along contours is widely recommended both to reduce runoff and protect terraces wherever such physical soil conservation measures are adopted (for example, see Wenner 1980). This soil conservation benefit of woody perennials can be conveniently exploited in agroforestry if the chosen species can provide additional benefits and outputs such as fodder, fuel, wood, food, etc. The long tradition of planting *Leucaena leucocephala* in contour hedges for erosion control and soil improvement in Southeast Asia, especially Indonesia, is a typical example. Indirect terraces are also formed when the washed-off soil is collected behind the hedges. Loppings and prunings from such hedgerow species could also provide mulch to aid in preventing sheet erosion between trees. An example of this principle being translated into practice can be found in the GTZ (Germany)-sponsored project in Nyabisindu, Rwanda (Zeuner 1981, Neumann 1983). The presence of more plant cover on the soil, either live or as mulch, also reduces the impact of raindrops on the soil and thus minimizes splash and sheet erosion. Therefore, as pointed out by Lundgren & Nair (1983), the potential role of agroforestry in soil conservation lies not only in woody perennials acting as a physical barrier against erosive forces, but also in providing mulch and/or fodder and fuelwood at the same time.

Another protective function of woody perennials in agroforestry is their role as shelterbelts and windbreaks. Use of trees and other woody perennials to protect agricultural fields from the adverse effects of wind is a wide-spread practice in many agricultural systems. The principle can be of considerable value in developing sound agroforestry technologies for areas that are prone to wind damage. Very encouraging results in this direction have, for example, been obtained at the Pakistan Forestry Research Institute, Peshawar (Sheikh & Chima 1976, Sheikh & Khalique 1982). Darnhofer (1982) examined the physical, ecological and biological considerations involved in the design of agroforestry shelterbelts and felt that the design has to be site-specific depending on large number of factors such as major components of farming systems (crops/livestock), desired pattern of windbreak (simple, multiple (successive), network system (with or without secondary hedgerows) etc.

LEGUMINOUS WOODY PERENNIALS FOR AGROFORESTRY

From the foregoing, it is evident that legumes are not the only woody species that have potential role in agroforestry. However, the family Leguminosae offers by far the maximum range of choice of woody species for agroforestry in terms of their economic uses as well as ecological adaptability. The greatest advantage attributed to the legumes is their capability for nitrogen fixation. Although legumes are not the only nitrogen fixers (others include, for example, the genera *Alnus* and tropical *Casuarina*), and all legumes are not necessary N_2-fixers, there is a general tendency albeit erroneously, to equate N_2-fixation with legumes. As pointed out by Brewbaker & Ta Wei Hu (1981), the 18,000 species of the family Leguminosae include the vast majority of important nitrogen fixing trees (NFT), many of which are in the predominantly woody subfamilies Mimosoideae (2,800 spp.) and Caesalpinioideae (2,800 spp.).

Out of the species tested by the authors, a high proportion of the mimosoids (92%) and papilionoids (94%) were able to fix nitrogen, contrasted with caesalpinioids (34%). For a detailed discussion on the role of woody legumes in agroforestry vis-a-vis N_2-fixation, see Nair (1983c).

Plants, especially woody species, that have hitherto been very little studied may prove themselves to be very valuable for agroforestry. Prime candidates will be species that can grow well with other species, that can thrive in environments that are too harsh for most other species, that simultaneously yield several products (food, fuel, fodder), that enrich the micro-site such as by nitrogen fixation, efficient nutrient cycling or addition of organic matter to the soil through litterfall and decay. Growth habits of such species with respect to their above-found and below-ground parts will also be of considerable significance. With this long list of attributes it would be possible to prepare a check-list of characters to look for, or suggest some ideo-types of woody plants for agroforestry. Although such approaches are certainly useful in the long-term selection process, expediency demands that we look for some of these characters in the trees that are commonly found to exist in agricultural lands - either mixed with agricultural crops or otherwise retained deliberately. Several such studies have recently been initiated in various places (G. Poulson 1981: personal communication - about 100 woody species that are potentially suitable for agroforestry in Kenya; National Academy of Sciences 1975, 1980; Hecht 1982, etc.). However, such studies are often not necessarily limited to legumes, although legumes dominate all the lists, as mentioned earlier. Some such studies are also being undertaken exclusively on economically important nitrogen fixing tree species (for example, Vergara 1982, Brewbaker et al. 1983).

A summary of characteristics and descriptions of a few woody leguminous species having potential role in different agroforestry systems under various ecological conditions is compiled in Table 4 as an indicative example. The possible uses and functions of the species are also indicated in the Table. This Table along with the previous one (Table 3) gives a good indication of the potential role of woody leguminous species in agroforestry systems under diverse ecological conditions.

In addition to the trees and shrubs on which such information is available, there are also many other species which have not thus far been studied. Undoubtedly, one of the most promising opportunities in agroforestry lies in tapping this hitherto unexploited potentials of this large number of multipurpose trees and shrubs.

ICRAF'S FIELD TRIALS ON LEGUMINOUS TREES AND SHRUBS FOR AGROFORESTRY

There is an understandable but unfortunate tendency in the present "enthusiasm and awareness" stage of agroforestry development to exaggerate the supposed benefits of agroforestry systems and

TABLE 4a. Characteristics and uses of some leguminous and other nitrogen fixing woody perennials with agroforestry potential.

Major Ecological Zone	Species	Ecological adeptability				Crown form	Management aspects				
		Altitude (m.a.s.l.)	Rainfall range (mm/yr)	Maximum dry period (months per year)	Soil conditions		Establishment	Seed treatment	Care	Coppicing ability	
Arid/Semi-arid	*Acacia albida*	up to 1,200 m	300 - 800	6 - 8	Sandy/silty well drained soils. Good tolerance to salinity	Tree to 30 m	Seedlings	Hot water (80°C) & soak 24 hours	Weeding	poor	Leafless in rains
	A. senegal	up to 1,700 m	200 - 800	8 - 11	Sandy/well drained soils. pH 5-8 poor tolerance to waterlogging	Tree 5 to 15 m	Seedlings	Hot water (80°C) & soak 24 hours	Weeding	good	Browse susceptible
	A. tortilis	up to 1,500 m	100 - 1,000	10 - 12	Alkaline and sandy soils. Good tolerance to salinity	Tree flat top 4-30 m	Seedlings	Hot water (80°C) & soak 24 hours	Weeding	good	Bruchids eat seeds
	Albizia lebbeck	up to 1,600 m	500 - 2,000	4 - 5	Prefers drained loams. Good tolerance to salinity	Tree 20-30 m spreading crown	Direct seeding, root/shoot cuttings	Boiling water & cool & soak 24 hrs	Weeding	good	Browse susceptible
	Cajanus cajan	up to 3,000 m	400 - 2,500	5 - 6	Light sandy soils and loams. Poor tolerance to waterlogging	Shrub 1-4 m	Direct seeding	None. Use fresh seeds	Weeding for first 4-6 weeks	good at 0.15 m	Shade intolerant
	Cassia siamea	up to 1,200 m	500 - 1,000	4 - 5	Most soils including limestone & laterite. Poor tolerance to waterlogging	Tree 15-20 m. Dense crown	Direct seeding	Hot water (80°C) & soak	Weeding for first 2 years	good	Browse susceptible
	Cordeauxia edulis	300 - 1,000 m	200 - 500	10 - 12	Sandy soils. pH 7-8.5; very poor tolerance to frost	Shrub 1-3 m	Direct seeding	None. Short seed viability (3 mths)			Frost sensitive
	Pithecellobium dulce	up to 1,500 m	400 1,600	4 - 5	Most soils including clay. Good tolerance to salinity and waterlogging	Tree 15-29 m	Seedlings or cuttings	None. 6 months seed viability	Very good tolerance to weeds	very good	Insects eat seeds
	Prosopis chilensis	300 - 2,900 m	200 - 600	8 - 11	Most soils. Good tolerance to salinity	Tree 8-15 m	Seedlings	Hot water (80°C) & soak 24 hours	Weeding in first year	?	Frost susceptible
	Prosopis cineraria	up to 1,000 m	75 - 850	8 - 10	Sandy/rocky soils. Tolerates pH 9, salinity and waterlogging	Tree 5-9 m Open crown	Seedlings or root suckers	Scarified & boilling water & soak	Good tolerance to weeds	good	Tolerates slight frost

* Fair
** Good
*** Excellent

Zone	Species	Food: Fruits/Pods	Food: Nuts/Seeds	Food: Vegetable	Food: Oils/Fats	Food: Starch	Food: Spices (S) Condiment (C)	Fodder: Leaves	Fodder: Fruit/Pods/Seeds	Fodder: Shoots	Fodder: Bee forage	Wood: Fuel wood	Wood: Charcoal	Wood: Building material	Wood: Wood for utensils & tools	Wood: Sawn timber	Wood: Others	Services: Windbreak	Services: Live fence	Services: Soil conservation	Services: Dune fixing	Services: N fixing	Services: Organic manure	Services: Mulch	Services: Others	Misc.: Waxes	Misc.: Essential oils	Misc.: Tannins (T) Dyes (D)	Misc.: Gums	Misc.: Fibres	Misc.: Medicinal/Drugs	Misc.: Cultural, ritual, social	Misc.: Ornamental	Misc.: Other	Other Remarks
Arid/Semi-arid	*Acacia albida*							**	*			*		*	*					**		**	**					(T) *					*		Combines well with agric. crops
	A. senegal		*					**	**			***	**							**	*	*							***	**	*				Yields gum arabic
	A. tortilis							**	**	*	**	***	**	**	**					**	**	*											*		Widely used for livestock pens. Termite resistant
	Albizia lebbeck							**		*	**	**		*		**				**		**	*						*				*		Fast growing
	Cajanus cajan		**	**				*	**	*		*								**		***							*				*		Sericulture/shellac
	Cassia siamea							*	*	*		***				**		**		**			**												Very toxic to pigs
	Cordeauxia edulis		***		**	**		**												*		*						(D) *							Subsistence food
	Pithecellobium dulce	*			*			**	**		**	*		*		*		*	**			*						(T) *	*				*		Presscake makes good stock feed
	Prosopis chilensis		*					*	*		*	*		**	*					**		*													High biomass yielder
	P. cineraria							**	**		*	***	**	*	*					**	**	**													Combines well with agric. species

TABLE 4b. Characteristics and uses of some leguminous and other nitrogen fixing woody perennials with agroforestry potential.

Major Ecological Zone	Species	Ecological adaptability: Altitude (m.a.s.l.)	Ecological adaptability: Rainfall range (mm/yr)	Ecological adaptability: Maximum dry period (months per year)	Ecological adaptability: Soil conditions	Crown form	Management aspects: Establishment	Management aspects: Seed treatment	Management aspects: Care	Management aspects: Coppicing ability	Management aspects: Special features
Humid/sub-humid	*Acacia auriculiformis*	up to 600 m	1,000 - 1,800	6 - 8	Wide range including Uranium and tin mining spoils. pH 3-9	Tree, 30 m	Direct seeding or seedlings	Boiling water & soak for 24 hours	Weeding	poor	Shallow roots
	Calliandra calothyrsus	up to 1,500 m	1,000 - 2,000	3 - 4	Wide range of soils. Very good tolerance to flooding	Shrub, 8-10 m	Direct seeding or seedlings	Boiling water & soak 24 hours	Good tolerance to weeds	excellent	1-2 year rotations
	Casuarina equisetifolia	up to 1,500 m	200 - 5,000	6 - 8	Most soils except clay. Tolerant to salinity and waterlogging	Tree, 30-50 m	Seedlings	Ant repellant on seed	Weeding	poor	N-fixing Actinomycete
	Derris indica	up to 1,200 m	800 - 2,500	4 - 6	Most soils including limestone. Very good tolerance to salinity	Tree, 5-8 m Deciduous	Direct seeding/ cuttings	None	Good tolerance to weeds	good	Shade tolerant
	Gliricidia sepium	up to 1,800 m	2,300	2 - 3	Moist or dry soils even when very alkaline	Tree, 8-10 m Open crown	Seedlings or large cuttings	Hot water (80°C) & soak 24 hours	?	good	Deciduous
	Leucaena leucocephala	best be - low 500 m	250 - 1,700	6 - 6	Poor growth on acid soils (< pH 5). Poor tolerance to waterlogging	Shrub/tree, 8-20 m	Direct seeding or seedlings	Hot water (80°C) soak 48-72 hours	Weeding	good	Frost sensitive
	Mimosa scabrella	up to 2,400 m	1,000 - 2,000	?	Most well drained soils. Poor tolerance to waterlogging	Shrub/tree 10-12 m	Direct seeding	?	?	?	3-4 year rotations
	Samanea saman	up to 1,000 m	600 - 2,500	5 - 6	Wide range of soils	Tree, 30-40 m Spreading crown	Seedlings	Feed pods to cattle	Good tolerance to weeds	?	Shallow roots
	Sesbania bispinosa	up to 1,200 m	550 - 1,100	5 - 6	Most soils. Very good tolerance to alkalinity, salinity and waterlogging	Shrub 1lls, 4 m	Direct seeding	None	Very good tolerance to weeds	-	An annual
	Sesbania grandiflora	up to 800 m	1,000 - 2,000	2 - 3	Wide range of soils. Good tolerance to waterlogging	Tree, 10 m	Direct seeding/ seedlings/cuttings	None	Little maintenance	good	Frost sensitive

* Fair
** Good
*** Excellent

Major Ecological Zone	Species	Functions/Uses: Food: Fruits/Pods	Nuts/Seeds	Vegetable	Oils/Fats	Starch	Spices (S) Condiment (C)	Fodder: Leaves	Fruits/Pods/Seeds	Shoots	Bee forage	Wood: Fuel wood	Charcoal	Building material	Wood for utensils & tools	Sawn timber	Others	Services: Windbreak	Live fence	Soil conservation	Dune fixing	N fixing	Organic manure	Mulch	Others	Miscellaneous: Waxes	Essential oils	Tannins (T) Dyes (D)	Gums	Fibres	Medicinal/Drugs	Cultural, ritual, social	Ornamental	Other	Other Remarks
Humid/sub-humid	*Acacia auriculiformis*											**	**				pulp			**		**						(T) *	*				**		Outgrows *Imperata cylindrica*
	Calliandra calothyrsus							**			*	**								**		**	**										*		Combines well with agric. species
	Casuarina equisetifolia							***				***	***	**	**		pulp	***		**	**	*						(T) *							Fire sensitive
	Derris indica							**				**			*					**	**	*					*		*	*					Insecticide properties
	Gliricidia sepium							**			**	**						**	***	**		*	**												Coffee/cocoa shade
	Leucaena leucocephala							***		**	**	**	**	*			pulp	**		**		**	***												Combines well with agric. species
	Mimosa scabrella											**					pulp		**			*	**										**		Coffee shade
	Samanea saman	*							**						**	**						**							*				**		Pasture shade
	Sesbania bispinosa							**				*					pulp	*		**	**	**								**					Combines well with agric. species
	Sesbania grandiflora	*		**				**	**			*					pulp	**		**		**	***					(T) *	*		*				Combines well with agric. species

TABLE 4c. Characteristics and uses of some leguminous and other nitrogen fixing woody perennials with agroforestry potential.

Major Ecological Zone	Species	Ecological adaptability: Altitude (m.a.s.l.)	Ecological adaptability: Rainfall range (mm/yr)	Ecological adaptability: Maximum dry period (months per year)	Ecological adaptability: Soil conditions	Crown form	Management aspects: Establishment	Management aspects: Seed treatment	Management aspects: Care	Management aspects: Coppicing ability	Management aspects: Special features
Tropical highlands	*Acacia mearnsii*	up to 2,000 m	500 - 1,200	4 - 5	Wide range except calcareous soils	Tree to 25 m	Direct seeding	Immerse in boiling water	Good tolerance to weeds	poor	Mod. frost tolerant
	Albizia stipulata	2,000 - 3,000 m	500 - 2,500	3 - 5	Well adapted to infertile and shallow soils	Tree 15-20 m	Seedlings, root/ shoot cuttings	None	Weeding	good	Highlands - Nepal
	Alnus acuminata	1,200 - 3,200 m	1,000 - 3,000	3 - 5	Well drained loams and loamy sands. Also on gravelly and clayey soils	Tree 15-40 m	Seedlings or root cuttings	None. 2-3 weeks seed viability	Weeding	good	Actinomycete *Frankia* sp.
	A. nepalensis	300 - 3,000 m	500 - 2,500	3 - 5	Wide range. Best on alluvial loams and loamy sands	Tree 30-40 m	Seedlings/cuttings	None	Good tolerance to weeds	fair	Shade tolerant
	Casuarina oligodon	up to 2,300 m	700 4,000	6 - 8	Most soil types	Tree 20-35 m	Seedlings	Ant repellent	Weeding	?	Mod. frost tolerant
	Erythrina poeppigiana	up to 2,000 m	1,000 - 3,000	3 - 5	Most soils; dry to wet	Tree 10-15 m	Seedlings/cuttings	?	?	good	
	Gliricidia tricanthos	up to 1,500 m	500 - 2,500	6 - 8	Most soils; acid to alkaline, sandy to clay	Tree to 45 m flat topped	Seedlings/cuttings	Immerse in hot water (80°C)	Good tolerance to weeds	good	Frost tolerant
	Inga jinicuil	up to 1,400 m	500 - 3,000	5 - 6	Most soils including limestone	Tree 10-20 m	Seedlings	Short seed viability	?	good	Termite susceptible
	Lespedeza bicolor	up to 2,000 m	500 - 2,500	3 - 5	Most types including infertile rocky soils	Shrub 2-3 m	Direct seeding or seedlings	None	Good tolerance to weeds	good	Korean species
	Trema orientalis	up to 2,000 m	1,000 - 3,000	3 - 4	Wide range including denuded infertile soils	Tree 10-15 m	Seedlings/cuttings	Refrigerate 2°C for 3-4 months	Good tolerance to weeds	good	Shade intolerant

* Fair
** Good
*** Excellent

Functions/Uses

Species	Food: Fruits/Pods	Food: Nuts/Seeds	Food: Vegetables	Food: Oils/Fats	Food: Starch	Food: Spices (S) Condiment (C)	Fodder: Leaves	Fodder: Fruit/Pods/Seeds	Fodder: Shoots	Fodder: Bee forage	Wood: Fuel wood	Wood: Charcoal	Wood: Building material	Wood: Wood for utensils & tools	Wood: Sawn timber	Wood: Others	Services: Windbreak	Services: Live fence	Services: Soil conservation	Services: Dune fixing	Services: N fixing	Services: Organic manure	Services: Mulch	Services: Others	Miscellaneous: Waxes	Miscellaneous: Essential oils	Miscellaneous: Tannins (T) Dyes (D)	Miscellaneous: Gums	Miscellaneous: Fibres	Miscellaneous: Medicinal/Drugs	Miscellaneous: Cultural, ritual, social	Miscellaneous: Ornamental	Miscellaneous: Other	Other Remarks
Tropical highlands	*Acacia mearnsii*										***	**				pulp			***		**	***					(T) ***							Combines well with agric species
	Albizia stipulata						***														**	**						*					**		Coffee/tea shade
	Alnus acuminata										**		**	**	*	pulp			***		**	*												Pasture trees
	Alnus nepalensis						*				*			**					***		**												*	Outgrows and suppresses most weeds
	Casuarina oligodon										***	**	**				***		**		*													Common fuelwood in Papua New Guinea
	Erythrina poeppigiana						**							*				**	**		**	**	*											Coffee shade
	Gliricidia tricanthos	*					**	**			**		**	**	*		**		**														*	Could become a weed
	Inga jinicuil						*						**						**		***	**												Coffee shade
	Lespedeza bicolor						**			**	**								***		**	**												Nurse/fallow species
	Trema orientalis						**				**	**	**			pulp			**		?													Cacao/coffee shade

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TABLE 5. Some growth characteristics of a few multipurpose leguminous woody perennials at ICRAF's Field Station, Machakos, Kenya.

Species	Date of planting	Number of plants measured	1. Height (m) (±S.D.)	2. Crown diameter (m) (±S.D.)	3. Stem diameter (cm) (±S.D.)	
					At base	1 m above ground
Acacia albida	28.10.81	45	1.77 (0.62)	1.24 (0.45)	4.09 (1.78)	2.12 (1.24)
Acacia cyanophylla	9.11.81	12	3.00 (0.62)	2.39 (0.51)	8.61 (1.88)	3.99 (1.48)
Acacia nilotica	9.11,81	12	1.66 (0.34)	2.57 (0.39)	6.46 (1.09)	1.87 (0.96)
Atriplex nummularia	30.10.81	104	1.95 (0.44)	1.22 (0.39)	-	-
Cassia alata	14.11.81	8	1.74 (0.67)	1.62 (0.41)	3.82 (1.63)	2.17 (1.43)
Cassia siamea	7.12.81	12	2.28 (0.46)	2.05 (0.42)	7.23 (1.42)	2.25 (0.70)
Casuarina equisetifolia	5.04.82	8	1.52 (0.46)	0.66 (0.23)	1.94 (0.83)	0.61 (0.40)
Erythrina abyssinica	11.12.82	12	0.82 (0.34)	1.09 (0.28)	4.36 (0.94)	-
Leucaena leucocephala (Cunn.)	9.11.81	12	2.40 (0.26)	2.03 (0.31)	6.78 (1.36)	2.93 (0.93)
Leucaena leucocephala (K8)	12.11.81	66	3.02 (0.59)	2.29 (0.42)	6.95 (1.14)	4.70 (1.15)
Leucaena leucocephala (Peru)	13.11.81	36	2.55 (0.52)	2.02 (0.40)	6.09 (1.19)	3.86 (1.09)
Parkinsonia aculeata	29.10.81	11	1.74 (0.23)	2.51 (0.25)	5.12 (0.40)	2.19 (0.38)
Prosopis juliflora	27.10.81	59	2.29 (0.53)	1.92 (0.55)	4.98 (1.29)	1.74 (0.78)
Prosopis palida	29.10.81	9	2.00 (0.37)	1.77 (0.59)	3.45 (0.94)	1.49 (0.70)
Sesbania grandiflora	19.04.82	42	2.40 (0.44)	1.61 (0.41)	10.15 (1.65)	3.83 (0.93)

Date of measurement: First week of July, 1983.

[1] Height was measured with a heightpole and/or metre ruler.

[2] Crown diameter was measured using a measuring tape. At least two measurements at right angles to one another were taken and an average obtained.

[3] Stem diameter was measured using vernier calipers. Two readings at right angles to one another were averaged. For multi-stemmed trees the average diameter of each stem was converted to basal area. The basal area of all the stems were summed and the corresponding diameter calculated.

components such as multipurpose trees and shrubs. In fact, these benefits have to be *achieved* through development of sound technologies based on research, rather than being merely *ascribed* to any land use practice that can fit itself into the broad definition and concept of agroforestry, or any tree or shrub that can be considered to be having a potential role in agroforestry. But in addition to the difficulty caused by the lack of adequate quantitative information on agroforestry systems and its components, there is also the problem of non-existence of appropriate methods to assess their suggested advantages and potentials in comparison with other systems and components. Therefore,most of the development programmes on agroforestry are, necessarily, based on rather *ad-hoc*, intuitive, and trial-and-error approach. But it is evident that if the enthusiasm on agroforestry is to be harnessed, and if the suggested advantages are to be exploited to any discernible extent, it is necessary that the gaps in our knowledge are bridged.

Though the primary objective of assembling the plants on ICRAF's Field Station is to aid in the Council's demonstration and training activities, the results are also of immense value from the point of view of their suitability for agroforestry in similar conditions elsewhere. Moreover, it is hoped that the plants will be made use of for developing methodologies for evaluating multipurpose trees and shrubs for agroforestry. About 35 species of multipurpose trees have been planted on the station starting from October 1981. Growth characteristics of a few leguminous ones among them are presented in Table 5.

CONCLUSIONS

It has been well recognized that agroforestry is a sound approach to land management in certain situations, and that multipurpose leguminous trees and shrubs offer a group of most promising species for agroforestry systems. However, various gaps exist in our knowledge on these plants: uniformity of genetic stock, plant arrangement and management in agroforestry systems, their compatibility with agricultural crops, improvement of plant architecture, etc. are important issues that need to be tackled by systematic research. It is our hope that this symposium will provide the necessary impetus for accelerating research endeavours on these aspects.

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