

NITROGEN FIXING TREES IN AFRICA: PRIORITIES AND RESEARCH AGENDA IN MULTIUSE EXPLOITATION OF PLANT RESOURCES

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ABSTRACT - Tropical Africa south of the Sahara consists of isolated areas of shifting cultivation and larger areas of more or less dense forests, bushes and grassland natural fallows. A few years of cultivation on slash and burn cleared land is alternated with varying periods of fallow during which soil fertility is recuperated if these periods are long enough. Legume trees play an important role in restoring soil fertility and are regular components of natural and also planted fallows. Besides many miscellaneous uses some of these trees have high protein and nutritious seeds for human and animal food. Other legume trees produce leaves which can be eaten as vegetables. These features together with agroforestry use for timber and fuelwood make tree legumes an important part of fallows. Research should concentrate on multiple utility of tree legumes and focalize agricultural systems which rely on them as nitrogen source for agriculture.

Index terms: N₂ fixation.

LEGUMINOSAS ARBÓREAS NA ÁFRICA: PRIORIDADES PARA PESQUISA SOBRE EXPLORAÇÃO MÚLTIPLA

RESUMO - A África tropical ao sul do Saara consiste de manchas isoladas de agricultura exploratória e de áreas maiores de florestas mais ou menos densas, savanas e prados naturais. Alguns anos de agricultura após queimada da vegetação natural são seguidos por períodos de comprimento variável de capoeiras, durante os quais a fertilidade do solo é restaurada se o tempo for suficientemente longo. As leguminosas arbóreas fazem parte importante das capoeiras, e trazem contribuição importante para a restauração da fertilidade do solo. Ao lado de muitas utilidades variadas, podem dar frutos ricos em proteína para a alimentação humana e animal e folhas que são usadas como verduras nas épocas escassas. Estas características, junto com as qualidades agroflorestais de produzir madeiras e lenha, fazem das leguminosas arbóreas a parte mais importante das capoeiras. A pesquisa deveria focalizar a utilidade múltipla destas espécies e desenvolver sistemas agrícolas baseados em nitrogênio proveniente desta fonte.

Termos para indexação: fixação de N₂.

INTRODUCTION

The prevailing farming systems in Africa south of the Sahara consist of isolated decreasing areas of shifting cultivation and larger areas of forest, bush, woodland thicket and grassland natural fallows. There are also planted fallows in some areas of high population density such as in parts of south-eastern

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Nigeria. In all these areas of traditional and transitional farming systems there is widespread reliance on the nutrient cycling by plants for the maintenance of soil fertility. Usually a few years of cultivation on slash and burn cleared land alternates with varying periods of fallow during which the soil fertility lost during the cultivation phase is replenished through leaf fall and plant residues containing nutrients absorbed by roots from the lower layers of the soil in addition to nitrogen of the air fixed in root nodules of leguminous plants. With increasing population density and pressures on the land, periods of fallow have been more shortened or reduced sometimes to less than one year. Under these conditions, the fallow periods are ineffective in the rejuvenation of the soil. The consequences of this is decline in soil fertility and productivity, soil degradation and soil erosion. This paper reviews the role of leguminous trees or shrubs in farming systems, current interest in nitrogen fixing plants, research priorities and suggestions on guidelines in research aimed at achieving multiple use of plants of which nitrogen fixation is but one component.

USES OF LEGUMINOUS AND NITROGEN FIXING SHRUBS AND TREES IN TROPICAL AFRICA

Apart from many leguminous probably nitrogen fixing trees and shrubs being regular components of natural or planted fallows in prevailing farming systems of tropical Africa, many of them have miscellaneous uses. Table 1 which is by no means exhaustive serves mainly to illustrate the ethnobotanical and range of uses of leguminous species. Some of them are regular cultivated crops, as for example the pigeon pea (*Cajanus cajan*) which may be found in dwarf herbaceous or shrubby woody forms. Others such as the African oil bean (*Pentaclethra macrophylla*) and *Parkia* spp. have high protein and nutritious seeds that are usually eaten after boiling and fermentation. They are found cultivated in homestead gardens or in outlying fields of the prevailing fallow systems. Some leguminous trees such as *Pterocarpus* species and *Azelia bella* var. *bella* produce leaves which are eaten as vegetables and are of nutritional strategic importance since they are available in the dry season when popular herbaceous vegetables are scarce. Shrubs and trees such as *Gliricidia sepium* and *Albizia* spp. are, since many years ago, used as shade plants in the production of plantation crops, for example cocoa and coffee. *Baphia nitida* (camwood) is a source of dye used for domestic purposes, a chewing stick used as substitute for tooth brush, a browse plant used for feeding goats and sheep in humid areas and is of religious importance in south-eastern Nigeria. *Acacia albida* is a well known nitrogen fixing shrub in savanna areas and other species of *Acacia* (e.g. *A. Senegal*) are sources of gum arabic. Some leguminous species are also of forestry and agroforestry significance. For example, *Azelia africana* is an important timber species that produces edible seeds. Similarly *Cassia* species (e.g. *C. siamea* and *C. nodosa*) are grown for their uses as sources of poles and fuelwood. Some non-legumes such as *Casuarina* are known to be nitrogen fixing and are grown for supply of poles, pit props for mines and fuelwood in addition to their ornamental uses in urban areas. Many of these trees may also be grown in forest plantations that serve to conserve the soil especially when they provide cover to steep or hilly slopes that otherwise would be seriously eroded under field crop farming. For more detailed review of the roles of legumes in the farming systems of tropical Africa reference should be made to Okigbo (1976a, b).

STATUS OF RESEARCH IN NITROGEN FIXING TREES

Until about a decade ago there was very limited interest in nitrogen fixing trees. High priority was given to studies in the growth and utilization of herbaceous legumes as sources of food, animal feed in pastures, fallow or cover crops in rotations with non-legumes and conservation crops. In the late 1930s and during the 1940s much interest was centered in Nigeria in the use of mucuna (*Stylobium deeringianum*) as a cover crop in the maintenance of soil fertility. There were investigations on the use of

TABLE I. List of selected leguminous probably nitrogen fixing shrubs and trees of agricultural, agroforestry and other uses in tropical Africa.

Species	Edible parts		Structural materials			Fallow cover	Shade trees	Fuelwood	Miscellaneous	Browse plants	
	Leaves	Seeds	Timber	Stakes and poles							Tool handles
<i>Acacia</i> species						X		X	Ga	X	
<i>Afzelia africana</i>		X	X					X			
<i>Afzelia bella</i> var. <i>bella</i>	X	X						X	O		
<i>Albizia</i> species				X		X		X	m		
<i>Anthoantha macrophylla</i>				X				X	d, r	X	
<i>Baphia nitida</i>								X	ro		
<i>Cajanus cajan</i>		X						X			
<i>Cassia</i> species				X				X			
<i>Casuarina equisetifolia</i> *				X				X	O		
<i>Daniella</i> species			X			X					
<i>Detarium</i> species	X		X						r	X	
<i>Dialium guianense</i>		X		X				X	cs		
<i>Flemingia congesta</i>											
<i>Gliricidia sepium</i>								X		X	
<i>Leucaena leucocephala</i>				X		X		X	O	X	
<i>Parkia lappertoniana</i>		X, p				X					
<i>Parkia biglobosa</i>		X, p				X					
<i>Parkia filicoides</i>		X, p				X					
<i>Pentaclethra macrophylla</i>		X						X		r	
<i>Prosopis</i> species		X, p						X			
<i>Prorocarpus</i> species	X							X			
<i>Sesbania</i> species						X					

* non-legume but nitrogen fixing

ga = gum arabic

o = ornamental

m = leaf litter used for mushroom growing

d = source of dye

r = religious artifact or uses

ro = crop rotational use

cs = chewing stick

Pueraria and *Centrosema* species as green manures, cover crops in plantation crops such as rubber and oil palms and as forage crops.

Leguminous trees mainly featured as shade trees in plantation crops such as cocoa and coffee. Their role as sources in biological nitrogen fixation in the maintenance of soil fertility was secondary. Research on longterm fallows in the maintenance of soil fertility in Nigeria involved traditional fallow species such as *Anthonotha macrophylla* and *Acioa bateri* in natural and/or planted fallows. It was then shown that especially in the highly weathered and leached soils of the humid tropics fallow shrubs that were effective in the maintenance of soil fertility were those that were active in nutrient cycling and not just those that mainly fixed nitrogen. The rosaceous shrub *Acioa bateri* was found to be suitable for establishment of planted fallows because of its deep root system, high leaf litter output in addition to being a preferred browse plant for goats. The pigeon pea was found to be more effective than *Pueraria*, *Calloponium* and other leguminous cover crops.

Current research on nitrogen fixing trees in various parts of tropical Africa is centered on the use of fast growing nitrogen fixing trees such as *Leucaena leucocephala* as fallow shrubs, in alley intercropping systems, for stakes and supply of fuelwood, etc. Interest in this work exists both in international agricultural research centers (IARCS) and national agricultural research institutions including Universities. Only aspects of work at IITA will be presented here. This includes studies in alley cropping, use of nitrogen fixing shrubs as stakes for viney crops and in preliminary agroforestry systems.

ALLEY CROPPING STUDIES

This involves the growing of field crops such as maize in between rows of different widths of *Leucaena leucocephala*. The studies include *Leucaena* establishment studies, nitrogen fixation potential assessment and yield evaluation of crops grown in alley cropping. The establishment studies showed that the *Leucaena* could be established during one year by planting it through a growing maize crop. Results of the alley cropping experiment reported in International Institute of Tropical Agriculture (1980) and Hartmans (1981) showed that:

1. There were draw backs with too narrow row widths (e.g. 2 m) or two wide ones (e.g. 8 m) but inter-row widths such as 4 m should allow use of mechanical equipment.
2. The *Leucaena* is pruned at certain intervals to prevent shading of the crop and enhance application of the prunings as mulch to the growing crop. About 100 kg/ha of nitrogen was contributed by 10 t/ha of prunings and the *Leucaena* mulch resulted in yields that compared favourably with results from plots with nitrogen fertilization.
3. The alley cropping system has the potential of maintaining soil fertility and productivity without the soil being tied down in long periods of fallow; thus, it constitutes one of the alternative systems for attaining sustained yields with reduced amounts of fertilizers.
4. Fast growing shrubs or trees such as *Leucaena* are suitable for staking yams and apart from eliminating cost of labor in cutting, carrying and digging in of stakes, they provide fuelwood which is now becoming scarce. *Leucaena* stakes effectively supported yams and wingbeans.

COMPARATIVE STUDIES ON GROWTH AND ESTABLISHMENT OF TREES

Studies on the growth and establishment of nitrogen fixing trees and other useful trees at Onne high rainfall station showed *Leucaena* to be the fastest in growth followed by *Gmelina*, *Gliricidia*, *Cordia*, *Flemingia*, *Treculia*, *Sesbania*, *Dialium*, *Irvingia* and *Dacryodes*.

PRELIMINARY AGROFORESTRY STUDIES

These are being jointly conducted with ILCA and have demonstrated the potentialities of *Leucaena*, *Gliricidia*, *Ficus* etc. as browse plants in fallows that are rotationally grazed with small ruminants.

PRIORITIES AND RESEARCH AGENDA ON NITROGEN FIXING TREES IN MULTI-USE SYSTEMS

Current research on fast growing shrubs and trees such as *Leucaena* have shown that these leguminous species provide a more effective alternative system than herbaceous species for maintenance of soil fertility and replacement of traditional fallows in continuous production systems for sustained yields. They are also sources of fuelwood stakes and browse for small ruminants. But research so far has given priority to fast growing exotic leguminous species such as *Leucaena* and *Gliricidia* that supply fuelwood of lower quality than traditional slower growing ones such as *Dialium*, *Acioa bateri* and *Anthonotha macrophylla*. They do not perform as well on certain soils as do such non-legumes as *Alchornea cordifolia* which is adapted to highly acid soils, Al-toxicity and higher water tables than *Gliricidia* and *Leucaena*. Moreover, there are many slower growing edible legumes (e.g. *Pterocarpus* species) and non-legumes (*Treculia africana*, *Irvingia gabonensis* and *Brachystegia eurycoma*) which are of potential in agroforestry that should receive some attention.

RECOMMENDATION AND AGENDA FOR RESEARCH

1. Fast growing nitrogen fixing trees can be effectively used in the development of efficient crop production systems for sustained yields at reduced cost on small farms. Research to enhance realization of their full potentials in development of more efficient farming systems and uses for miscellaneous purposes should continue to be pursued with vigor.

2. There are many leguminous species in the Caesalpinioideae such as *Anthonotha macrophylla* that already feature in traditional farming systems of tropical Africa but are not being studied. Moreover, there are several members of the Caesalpinioideae that constitute a large proportion of trees in the vegetation zones of the humid and sub-humid tropics. Their nitrogen fixing potentials need to be studied at various stages of growth.

3. Several non-leguminous shrubs and trees have potentials in nutrient cycling in highly leached soils of the tropics while at the same time playing various roles in prevailing farming systems and being useful to the farmer in various ways. Research should be carried out to preliminarily assess their potentials and promising species selected for further studies, improvement and use. Although these may not be fast growing they have the potentials of being grown in mixtures with fast growing trees and the complementarity in their uses may be enhanced in this manner.

4. Some leguminous and non-leguminous trees with edible fruits and shrubs such as *Pentaclethra macrophylla*, *Parkia* species, *Acacia* species and *Dialium guianense* contain oil and other useful substances

that may have industrial potentials. Moreover, they can grow on soils not suitable for arable crops at low input levels. Therefore, ways of utilizing them more effectively should be explored.

5. There is danger that the euphoria over potentials of fast growing trees may result in neglect of equally useful slower growing species. There is need for an evaluation of promising species so as to develop a more balanced program that makes adequate use of all potential species which may complement each other. Such an exercise also ensures that resources are not wasted in less promising species. Ways should be sought of making effective use of nitrogen fixing grasses, cycads and various other species in the development of new agricultural and agroforestry systems.

6. Many potentially useful leguminous and non-leguminous shrubs and trees in the tropics are not being studied or exploited. They are also threatened with extinction due to rapid disappearance of the forest ecosystems of tropical Africa under population pressure and reliance on clearing of more land as the most widespread method of increasing agricultural production.

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