ACACIA ALBIDA:

A FIELD MANUAL

Government of Chad and CARE-CHAD

Michael McGahuey, Forester
Robert Kirmse, CARE Project Manager

PRODUCED BY CARE-CHAD 1977
(AID/AFR-G-1251)

McGahuey

PROJECT

ACACIA ALBIDA EXPANSION PROJECT

— a field manual

JOINT PROJECT

GOVERNMENT OF CHAD AND CARE - CHAD

— Michael McGahuey, Forester
Robert Kirmse, CARE Project Manager

PRODUCED BY CARE-CHAD 1977

This field manual for the Acacia albida Project, which also includes the planting of Azadirachta indica and Commiphora africana or their equivalent, has been prepared by the CARE-Chad staff, 1976 - 1977, with the assistance of the Chadian Forestry Service.

The manual is written as part of USAID grant AID/afr-G-1251. The purpose of this Grant is to provide support to CARE for a project designed to establish the Acacia albida tree on farmers' fields as a recognized low-cost improved technology and as a means of increasing the farmers' capacity to improve his agricultural output and to establish the concepts of cultivating firewood as a domestic crop with concomitant protection of the environment.

The techniques and procedures in the manual are based primarily upon three years experience in the field working with 2,000 farmers in the planting of the Acacia albida. This field experience is heavily complemented by information gathered from other Sahelian and arid region projects.

This manual is primarily a field operations guide which describes the techniques, procedures and timetable which make up the implementation plan. It is not intended to be a technical document or a definitive final approach. It is hoped that this manual will be of help to anyone working in the field in the Sahel, and that it will serve as a forum for information and idea exchange.

REPUBLIQUE DU TCHAD

CONSEIL SUPERIEUR MILITAIRE

MINISTERE DU TOURISME DE L'ARTISANAT
& DES RESSOURCES NATURELLES

DIRECTION GENERALE

DIRECTION DES FORETS, DE LA CHASSE
ET DE L'ENVIRONNEMENT

N° /FCE

* Unité - Travail - Progrès *

N'Djaména, le 28 FEV. 1977

P R E F A C E

A L'INTRODUCTION DE LA CAMPAGNE ACACIA
A L B I D A -

ooO

Pourquoi Opération Acacia-Albida ?

Tout simplement parceque l'Acacia Albida appelé :

- Haraze en Arabe
- Dir en Sara
- Tchoutna en Massa

est un arbre très utile connu de nos paysans et ceux d'autres pays Africains. Cet grand arbre conserve un feuillage dense en saison sèche ; ses gousses et ses feuilles nourrissent le bétail en cette période difficile ; Enfin son ombrage est apprécié par les hommes et animaux au moment des fortes chaleurs.

- L'Acacia Albida perd entièrement son feuillage en saison des pluies ce qui améliore et conserve la fertilité du sol en augmentant la productivité des champs ; cette faculté de perdre ses feuilles en saison des pluies, permet au champ de bénéficier de toute la lumière du soleil nécessaire à la croissance des plants. (coton, mil, arachide etc).

- L'Acacia-Albida outre ses qualités agronomiques, fournit au paysan du bois de chauffe, de construction, pour la fabrication des ustensils (mortier, pilon) et divers outils (manchettes des houes etc).

Le Gouvernement conscient de tous les avantages de cet "arbre miracle" dont les éleveurs et les cultivateurs pourront bénéficier, décide d'intensifier sa plantation dans toutes les campagnes des zones rurales avec le concours des donateurs de Care-Tchad et de l'A.I.D.

Les plantations d'Acacia-Albida augmenteront la production agricole de nos paysans et résoudront en partie les problèmes de Conservations de la fertilité des sols et de deboisement offrant ainsi à la population le moyen efficace pour lutter contre ce fléau.

Ainsi le Gouvernement compte sur la participation effective des autorités administratives, Traditionnelles et Techniques pour que l'Opération Acacia-Albida soit une réalité Tchadienne pour le bonheur de nos masses paysannes en particulier, pour le Développement Economique et Social, Harmonieux de la République du Tchad en général./-

Le Directeur des Forêts, de la Chasses
et de l'Environnement

SARA TIYUERA

REPUBLIC OF CHAD

SUPREME MILITARY COUNCIL

MINISTRY OF TOURISM, CRAFTS
AND NATURAL RESOURCES

GENERAL DIRECTORATE

DEPARTMENT OF FORESTS, HUNTING
AND THE ENVIRONMENT

N° 105/FCE

N'Djamena, February 28, 1977

PREFACE
TO THE INTRODUCTION
OF THE ACACIA ALBIDA PROJECT

Why the Acacia albida Project?

Very simply because the Acacia albida tree called:

- Haraze in Arabic
- Dir in Sara
- Tchoutna in Massa

is a very useful tree, well known to our farmers and those of other African countries. This large tree retains its dense foliage during the dry season; its seed pods and leaves provide nourishment for cattle during this difficult period; and its shade is appreciated by both man and animals during the hottest periods.

The Acacia albida loses its leaves entirely during the rainy season which helps conserve and improve the fertility of the soil, thereby increasing field production; this ability to lose its leaves during the rainy season allows the fields to benefit from all the sunlight necessary for crops to grow (cotton, millet, peanuts, etc.).

The Acacia albida, in addition to its agronomic qualities, provides the farmer with firewood, construction wood, wood for making utensils (mortars, pestles) and tools (handles for hoes, etc.).

The Government of Chad, recognizing the benefits that this "miracle tree" can provide to the farmers and herdsmen, has decided to intensify its planting in grain fields in rural zones, in cooperation with the donors of CARE-Chad and with USAID.

The planting of the Acacia albida will increase the agricultural production of our farmers and resolve, in part, the problem of soil conservation and deforestation, thus offering the people an effective means to fight against famine.

The Government of Chad is also counting on the effective participation of all administrative authorities, both traditional and technical, to make the Acacia albida Operation a Chadian achievement for the well-being of our people in particular, and for the Economic and Social Development of the Republic of Chad in general.

The Director of Forests, Hunting
and the Environment

BABA DIGUERA

TABLE OF CONTENTS

		Page No.
Face Page		
Introduction		1
I.	Time Frame for Implementation	3
II.	Soil Regeneration with the *Acacia albida*	6
A.	The *Acacia albida* Tree	6
	1. The Tree and the Sahel	6
	2. The Natural History of the *Acacia albida*: its habitat, tap root, growth and development	9
B.	The Farmer and Site Selection for the Acacia albida Plantations	11
	1. The Official Visit	11
	2. The Initial Village Visit	11
	3. Village Meeting, Candidate Selection and Field Lay-Out	12
	4. The Farmer Education Component	15
C.	The Nursery for the *Acacia albida*	16
	1. The Nursery Site Selection	16
	2. The Nursery Lay-Out	17
	3. The Potting Mixture: collection of soil, mixing of soil, and filling of pots	20
	4. The Collection and Storage of Seed	21
	5. The Sowing of the Seeds	22
	6. The Transplanting of Seedlings	23
	7. The Regular Control of Nursery Stock: watering, mulching, crust-control, shading, weeding, insect control and pruning	23
D.	Picket Procurement and Treatment	27
E.	Pre-Positioning and Planting-Out of the *Acacia albida*	29
	1. The Timing	29
	2. The Pre-Positioning Operations	29
	3. The Planting-Out Operations	30
	4. Emergency Planting Technique	32
	5. Direct Seeding	32
F.	Post-Planting Operations	34
	1. The Cleaning or 'Releasing' Operation	34
	2. Fencing: Thorn-bush, millet stalk and pre-fabricated fences	35
	3. Insect Control	37
	4. The Surveillance Operation	38
	5. The Replacement Operation (Beating-Up)	39

TABLE OF CONTENTS

		Page No.
III.	Windbreaks and Village Wood Sources	40
	A. The Need for a Village Wood Supply	40
	B. Site Selection	41
	C. Field Operations	41
	D. Tree Species for Windbreaks and Wood Stands	43
IV.	Live-Fencing - Deflection Barriers	45
	A. The Need for Protection	45
	B. The Species: Uses and Establishment	46
	C. Site Selection and Live Fence Establishment	47
V.	Personnel and Administration - The Delivery System	48
	A. The Dual Needs of New Technology	48
	B. Personnel Responsibility Schedule	49
	C. The Farmer Incentive Component	52
	D. The Field Report Schedule	53
VI.	Tool and Material Requirements	56
VII.	Forms and Contracts	59
VIII.	Photographs	76
IX.	Technical Appendix	119

INTRODUCTION

In the Sahel, the farmers' land is the basis of his country's livelihood. Food, fuel and shelter come from the land. The rural ~~economy~~ economy is based upon the surplus harvested from the land.

At present, the Sahelian farmers face a very real paradox. On the one hand they have adequate quantities of soil, sun and rainfall; on the other they are faced with erratic rainfall distribution, intense sun and wind, and increasing pressure to produce more from a given amount of land. When the above conditions are coupled with an outmoded system of land-use, the farmer finds himself in a marginal position with very little hope of improvement.

To help ameliorate the deteriorating situation, CARE, at the request of the Chadian Government, has planned and implemented the Acacia albida Project, a farmland restoration program. This project introduces the self-help and multi-purpose land-use concepts to small farmers. The hub of the project is the establishment of stands of the Acacia albida tree in the grain fields of the farmers. This tree has a reverse deciduous cycle whereby it defoliates at the onset of the planting season. The land can be planted in grain while receiving year-round vegetative cover from the harsh Sahelian elements. Furthermore, the plants which are grown under the crown of the Acacia albida are generally superior to the plants grown in the open. (Studies of fields populated by the Acacia albida point to an average increase in grain production of 30% as compared to bare fields). These fields with stands of Acacia albida generally require little or no fallowing. This is in contrast to open fields which require fallowing in at least one year in two; or worse, many fields are cropped until rendered useless. Thus through the establishment of stands of the Acacia albida tree, farmland, the country's essential capital, is expanded.

To complement the Acacia albida plantings, the project includes two other components:

a) Village tree plantings will protect the land and the people from the elements and will provide fuel and construction materials.
b) Establishment of live fences will allow the farmer and the gardener the basic means to protect and control his land and crops against damage from animals.

In the implementation of these concepts, the Acacia albida Project follows the CARE partnership policy, whereby CARE works with the Chadian Forestry Service to reach the small farmer. CARE is establishing a management and logistical structure within which the Chadian Forestry Service field agents may operate effectively.

In recognizing the fact that the introduction of new concepts is difficult, the Acacia albida Project employs simple but proven techniques which are based on local resources. The project expects to establish an effective field cadre which works with the individual farmer. The fact that the techniques are simple allows the rapid formation and deployment of the field cadre and greatly diminishes the amount of material support. Thus, a multiplier-effect in the advancement of the new concepts can be more effectively realized than if the program required a higher level of technology and more imported materials.

The methods employed in this project are designed to aid the individual farmer to most effectively use his land and other natural resources to increase food and fiber production. The goal of the project is that a sufficient number of participating farmers benefit from the methods of the project so that a solid model is formed for other Chadian farmers. Over the course of the four years of this project, CARE and the Chadian Forestry Service are working with 2,000 farmers farmers on 3,500 hectares of farmland. The farmer, for his part, plants a minimum of 200 Acacia albida trees and is responsible for protecting and managing the stand and for maintaining a minimum number of trees in that stand.

I. Time Frame for Implementation

The following is a chronologically listed schedule of operations for the implementation of the combined aspects of the project: soil regeneration operations, windbreaks and live-fencing.

The dates are a time frame for the execution of individual operations. Certain critical dates such as those for the collection of seeds, the time for seeding, and the planting out operations are set by vegetative processes or climatic conditions, and may be neither advanced nor delayed. Operations such as the selection of farmers and the collection of pickets, which are not necessarily fixed by natural conditions, may be altered according to local conditions, but it must be kept in mind that critical activities require the successful completion of a number of other activities.

In all possible cases, operations are less intensified during the very hot periods of March and April and during the farmer's busy period of cultivation and harvest of May-June and October-November.

Further explanation of the timing determinants for each stage of operation may be found in the relative section of the text.

Beginning date	Completion date	Operation
1st week Nov.	4th week Dec.	- Site selection official visits (Acacia)
2nd week Nov.	1st week Jan.	- Initial village visit (Acacia)
3rd week Nov.	2nd week Jan.	- Village General meetings and candidate selection (Acacia)
3rd. week Nov.	2nd week Jan.	- Location of warehouse
3rd week Nov.	3rd week Jan.	- Stake collection by farmer for layout of his Acacia albida field
3rd week Nov.	4th week Feb.	- Layout of fields (Acacia)
1st week Nov.	4th week Feb.	- Collection of pickets
1st week Nov.	4th week Feb.	- Treatment of pickets
1st week Nov.	4th week Feb.	- Transportation of pickets to nursery or directly to site if convenient
1st week Dec.	4th week Feb.	-*Seed collection: Acacia albida, and storage
1st week Dec.	4th week Jan.	-*Seed collection: Neem
		-*Seed collection: Zizuphus sp.
		-*Seed collection: Balanites

*Denotes critical dates

Beginning date	Completion date	Operation
1st week Dec.	4th week April	- Construction of prefabricated fences by participating farmers
1st week Nov.	4th week Jan.	- Nursery site selection
3rd week Dec.	4th week Jan.	- Nursery layout
1st week Jan.	4th week Feb.	- Collection of potting soil
1st week Jan.	4th week Feb.	- Soil preparation for potting
1st week Jan.	2nd week Jan.	- Filling neem pots with soil
3rd week Jan.	4th week Jan.	- Seeding of Neem
1st week Feb.	4th week Feb.	- Site selection and field layout for windbreaks and village firewood source
2nd week March		- Windbreak & village forest reports due
1st week March	4th week March	- Live fencing site selection and demarcation
2nd week April		- Live fencing site selection report due
1st week March	4th week March	- Filling Acacia albida pots with soil
1st week April	3rd week April	- Pregermination of Acacia albida seeds
2nd week April	3rd week April	-*Seeding of Acacia albida pots; beating-up report
1st week April	3rd week April	- Seeding of seed beds
3rd week April	4th week April	- Transplant of Acacia albida
2nd week April	2nd week July	- Nusery stock care, watering, mulching, crust control, weeding, shading, insect control, and pruning
1st week May	3rd week May	- Field reports for prepositioning of pickets and seedlings
1st week May	2nd week June	- Transport of pickets to sites from nursery
3rd week May	2nd week June	- Seeding live fencing
4th week May	1st week June	- Hardening off of Acacia albida
3rd week June	2nd week July	- Pre-positioning (transporting) of Acacia albida to site
3rd week June	4th week June	- Transporting of Neem to site
2nd week July	4th week July	-*Planting of all trees
1st week Aug.	2nd week Aug.	- Survey results and correct problem; note fallow fields
3rd week Aug.		- Planting report due
1st week Aug.	2nd week Aug.	- Transport of replacement trees
1st week Aug.	2nd week Aug.	- Planting of losses - current years and previous year - Acacia albida only
3rd week Aug.	2nd week Sept.	- Releasing trees in fallow with hoe
4th week Sept.		- Releasing report due

Denotes critical dates

Beginning date	Completion date	Operation
3rd week Aug.	2nd week Sept.	- Picket placement in fallow fields
3rd week Aug.	(As necessary)	- Insect control treatment in fallow fields
4th week Aug.	2nd week Sept.	- Deleaf and prune Neems
1st week Aug.	3rd week Sept.	- Fence around Neems
3rd week Sept.	4th week Sept.	- Survey all plantations for correct cleaning (releasing), picket placement, and insect control
1st week Sept.	4th week Sept.	- Clean and protect live fences
2nd week Sept.	4th week Sept.	- Gather thorny branches for Acacia albida fence
2nd week Sept.	1st week Oct.	- Treat thorny branches with insecticide
2nd week Sept.	1st week Oct.	- Treat prefabricated fences with insecticide
4th week Sept.	4th week Oct.	- Tie and sticker picket fences for Acacia albida in fallow fields
4th week Sept.	4th week Oct.	- Place prefabricated fences in fallow fields
October	December	-*Clean around all trees after harvest with rake for fire control
October	December	-*Tie and sticker picket fences in grain fields after harvest
October	December	- Place prefabricated fences in grain fields
Immediately upon completion of the above		- General survey, fire control, losses and fencing
2nd week Dec.		- Fencing report due

II. Soil Regeneration with the Acacia albida

A. The Acacia albida Tree

1. The Tree and the Sahel

The soils of the Sahel are among the most volatile in the world in terms of fertility and structure. The intense sun, the long periods of drought, the short but intense rainfalls, the gusty and drying winds, and the sparse vegetative cover all contribute to the poor soil conditions for the support of an agricultural economy. Furthermore, the increasing pressure to produce more food and fiber is greatly aggravating the potential of the given amount of land. However, there exists simple but tried techniques which can play a major role in turning the situation around in the Sahel.

In former times, when there was less pressure on the land, farmers would clear an area with axe and fire, and farm it for five or six years. He could then leave it for a 15 or 20 year fallow period as he moved into another area and started the same cycle. With the present increase in demand for more grain and fiber, more wood products, and more animal protein, the land is often overly cropped before it is turned to fallow. Thus, even in a state of fallow, so much has been taken from it and so much stress from fire and over-grazing is placed on it, that it requires an even longer time to regain its viability.

Therefore, with the increased demand placed upon it, arable land is obviously limited. The question then becomes: what happens when all the cultivated land has been farmed and only fallow, sterile soils remain? The task is to avoid this happening as well as to improve upon the present quality of the soils.

The Acacia albida tree has demonstrated, through observation of natural stands, its ability to improve and sustain the productive capacity of farmland. The two remarkable characteristics of this indigenous species are its reverse deciduous cycle and its extraordinary taproot. The former allows crop production to take place under its crown during the rainy season and the latter allows the tree access to deeper layers of soil. In this manner large amounts of minerals are recycled at a strategic time to increase the amount of available nutrients to the crops.

The Acacia albida's utility has long been appreciated by a number of sahelian farmers. In some areas, documents show that it has been a

protected species for at least a century. The tree is often sought out by some farmers as a planting site for more valuable crops such as corn. The tree has received widespread interest from the scientific community only in the last 25 years; however, their findings support the experience of many sahelian farmers.

Beyond its agricultural importance, it is very important as dry season fodder In fact, it is reportedly higher in nutritional value than many, if not most other, sahelian plants. As attested to by the difficulty incurred in protecting the sapling from browsing animals, it is a preferred species. Not only are the leaves readily browsed, but the fruits are a much sought dry-season fodder.

As to the exact reasons why it benefits crop production, not everyone is totally in agreement. However, here are some probable reasons:

1. Green Manure: The leaves are dropped at the onset of the rains, allowing better conditions for decomposition. (The timing of defoliation is counter to most sahelian perennials which lose their leaves in the dry season).
2. Amelioration of Micro-Climate: The Acacia albida affords the crop and soil measurable benefits from decreases in temperatures and transevaporation, by physically breaking the full intensity of the wind and sun. These benefits in turn lessen moisture stress and ameliorate the conditions required for micro-bacterial activity. In short, it is probable that the micro-climate created by an Acacia albida tree affords the crop, under its crown, a slight but critical margin which is reflected in a higher average of production.
3. Protection against the Impacting Force of the Raindrop: The 'splash effect' of the falling raindrop is recognized as a major source of erosion. The solution to this problem is vegetative cover which will absorb the impact of the raindrop. The Acacia albida, with its reverse deciduous cycle affords this protection while allowing annuals to be cropped.
4. Enrichment and Concentration of Animal Droppings: Minerals consumed by an animal are imparted to the soil in the manure of the animal. In a recent study of the mineral content of the vegetative litter of three sahelain fodders, the Acacia albida litter was shown to be superior in most cases. Foraging animals demonstrate this property of the Acacia albida by preferring its leaves and fruit to most other feeds. In

recognition of the nutritional value of the tree, mature Acacia albida are heavily pruned by herders to allow the animals to browse the leaves and fruit.

By providing dry season fodder and shade, the tree attracts the browsing animals. In this fashion much of the manure is concentrated in the fields instead of in the fallow areas.

5. The Root System: As previously stated, the litter of the Acacia albida is relatively high in minerals. The tree has an extraordinary taproot which gives it a wider access to the soil profile. Given the high rate of leaching in many sahelian soils, the long range of the taproot could be significant. Furthermore, the double properties of reverse defoliation cycle and high palatability of leaves and fruit allow efficient release of the minerals to the top soil.
6. Atmospheric Nitrogen-Fixation: The Acacia albida is a Leguminosae and a potential means of nitrogen-fixation. However, reports and observations indicate few nodules. This is as yet a very interesting point.
7. Rainfall Deposits: Rainfall often washes or leaches relatively large amounts of mineral nutrients from the leaves of trees. Dust, ash, and other airborne particles are washed from the tree leaves down to the soil. Furthermore, certain minerals such as Potassium, Sodium and Calcium contained in the leaf can be dissolved by rainwater and thereby quickly returned to the soil. In fact, in many parts of the world, the weight of the minerals washed or leached to the soil by rainfall is greater than that which is returned to the soil by decomposed leaf litter.

The efficacy of this phenomenum as regards the Acacia albida and its ability to recycle mineral nutrients is not established. However, the fact that the leaf and fruit of the tree have a high content of some essential minerals, makes an interesting relationship.

2. The Natural History of the Acacia albida

2. Habitat

Although found on a variety of soils and under a variety of conditions, the Acacia albida is most often associated with grain fields in the Sahel. The Acacia albida can be found on clays or in zones inundated several months of the year, but the tree seems to thrive best on deep millet sands.

The major means of dispersal of the species is foraging animals. The fruit is eaten and most of the seeds are passed undigested through the digestive tract. The digestive acids break down the hard coat of the seed and allow penetration of moisture which in turn starts the germination process. The fact that the animals forage in the grain fields may be a factor in the presence of seedlings in those fields. (An interesting means of artificial establishment of Acacia albida stands is the feeding of animals the fruit of the tree and then bedding them down in the desired site).

The Acacia albida is often found thriving in grain fields; however, it is observed to experience relative difficulty in establishing itself in grasslands. There are two evident reasons for this: competition from the wild pioneer grasses and intolerance to heavy shade. When heavily shaded, the leaves of the sapling take on a yellowish, unhealthy appearance. Furthermore, the wild grasses are stronger competition for soil moisture than are cultivated crops.

Long Tap Root

Like other Acacia, the albida has an extraordinary taproot. However, the development of this root is affected by the environment of the tree. In its natural setting where there is a strong stress placed upon the available moisture supply, the growth of the taproot may exceed the growth of the sprout by six or seven lengths. What is more, the hair root system is concentrated at the end of the taproot. By comparison, the root-stem ratio in the nursery is often 1:1. This ratio is accompanied by a vigorous and extensive system of lateral roots.

Growth and Development

Jung reports from Senegal (1964) that productive agricultural lands have 10 to 15 trees per hectare. In the agricultural belt of Niger,

they are often found at 20 to 25 per hectare. It is interesting to note that the grain fields in many of these areas support crops without having to be turned to fallow. There are also young stands of Acacia albida which are quite dense. These stands indicate that benefits of the tree may be realized in a shorter time than normally estimated.

Given the correct conditions for establishment and growth, a one year old tree can reach a height of over a meter and a half. However, it is more common to find a one year old sapling no more than 60 cm high and very bushy. Although the benefits derived from the establishment of the relatively slow growing Acacia albida trees are not as dramatic as those transformations brought about by the application of chemical fertilizers, the benefits are realized in a geometrically increasing manner and are permanent. Furthermore, while the benefits of modern technology may offer hope, the implementation may be years away because of the relatively complicated technology and dependence upon modern materials.

The Acacia albida project addresses itself to the problems of the numerous subsistant farmers who do not have access to new technology nor realize enough of a profit from their crops to enable them to buy fertilizer and other components of that technology. The project expects to give the farmer basic and proven techniques which are based on locally available materials and which can be applied to solving the critical need for increased land productivity.

B. The Farmer and Site Selection for the Acacia albida Plantations

Selection of plantation sites will be made very early in order to be able to preview the nursery requirement for the area and be assured of local participation. The selection process will be initiated by a selection team consisting of a CARE representative and a Chadian Forestry Service Technical Official. The procedure will involve three stages: official visit, initial village visit, and village general meeting and candidate selection.

1. The Official Visit

In accordance with Chadian protocol, contact is first made with the Préfet of the Department. The Forestry Service sends a telegram, or otherwise notifies the Préfet of the visit by the Project management team. The team arrives at the departmental seat at the designated date and meets with the préfet and other officials. In each case, the purpose of the project is explained using visual aids. The officials of the prefecture are made to feel part of the project by being requested to assist at all levels. Their assistance, especially in the selection of candidates can be very valuable, and should be solicited at this time. If protocol is ignored, the project will have little chance of success.

The Préfet or the Sous-Préfet is requested to put the team in official contact with several villages that they consider will meet the project's standards. It is desirable that the team be accompanied by an official on the initial visit. In order to get a feeling as to the farmer's knowledge of the value of the Acacia albida tree and his receptiveness to the project, random visits are made to fields in order to get a sampling of opinion. Hopefully, this step leads to more informal dialogue about the project. The official visit and the initiation of the selection process, as it were, should begin the first week of November.

2. Initial Village Visit

First contact with the villages, or with the people of selected areas, is made by the Project Management Team, accompanied by a representative of the local administration. First contact is with the chief of the area who is questioned about his knowledge of the Acacia albida tree, and then told of the purpose of the project. Visual aids will be

used where possible. His opinion as to whether the people in his area would be interested in planting the tree is solicited and, if positive, permission is requested to visit several farmers and their fields.

As with the chief, the farmer is asked if he knows the Acacia albida tree, what he knows about it, and if he would consider planting and protecting it. For this the questionnaire form (enquête) may be used. A physical inspection is then made of the terrain to determine the suitability for planting. Such things to be noted are: whether the Acacia albida grows naturally in the area, whether the soil is relatively light, and whether the farm is used for sorghum and millet cultivation. Care should be taken to ensure that the area is not flooded or marshy as this type of land is generally not suitable for the planting of millet and sorghum. Furthermore, land used primarily for cotton production is not acceptable because the Acacia albida project is primarily aimed toward increasing food production.

If, in the opinion of the site selection team, the area is suitable for planting the Acacia albida tree, and if there is sufficient response from the farmer, a date is set for a return visit and a general meeting with all the farmers in any selected zone. Normally this meeting takes place no later than two weeks after the initial visit.

3. Village Meeting, Candidate Selection and Field-Layout

The project management team along with the Forestry Service field supervisor or field technician assigned to the area, returns to the village on the pre-arranged date for a meeting with the interested farmers and their chief. The team will arrive with 200 stakes, a wheelbarrow, a supply of hatchets, cords, sample tools, and samples of foods.

General meeting: A general discussion is held to explain the purpose of the project and to recruit farmers to participate in it. The questionnaire form and visual aids are useful for this discussion. The primary purpose of this meeting is to ensure that the farmer fully understands the purpose of the project. After first emphasizing voluntary participation, there will be an explanation of the assistance through tools and foods. A sample of each may be demonstrated at this time. It is explained that neither the tools nor the food are payments for work but that they are rather to help the farmer do extra

work which will eventually make him more self-sufficient. Furthermore, the tools are given out on a loan basis and become the property of the farmer only after successful participation in the project. It should be emphasized that because the tools and food are not payments, they are not to be sold.

Candidate selection: At the present time the only firm criteria for a farmer's selection is that the land be suitable for the planting of the *Acacia albida*, that the farmer is the owner of at least two hectares of grain-producing land and that there is reasonable access to the land. There may be some peer interplay or some reaction from the village notables to a selection. Any problems arising in the selection process are handled on a case by case basis. The process should be witnessed by a representative of the local Administration or Sultan in the case of disputes.

The candidates are signed up and given a hatchet on a loan basis. The candidate is to understand that he will be able to keep the tools after the requisite number of trees have survived the first growing season. A demonstration of staking out the land will be made in which all farmers are requested to participate. The demonstration field will normally be the chief's farm. At this demonstration, the farmers are to understand that they are responsible for staking, planting, protecting and managing their own trees.

After the demonstration of the field lay-out (see next section for one method), the participants organize themselves into groups of five or ten farmers. Each group is lent a number of hammers, hatchets, and is supplied with the requisite number of stakes. The field supervisor sets a time-frame for each group, within which the group has disposition of eelbarrows and cord; however, the village as a whole should be aware that a time limit exists for the termination of the lay-out work. Furthermore, only those farmers who have successfully terminated the lay-out work before the end of the third week of the month receive the monthly food ration. Therefore, each farmer is encouraged to carry his pickets to the field as best he can to avoid any transport bottleneck.

In order to establish the fact that the tools are only on loan until after one full year of successful participation, the tools of each group, the wheelbarrows and the cords are returned to the tool warehouse at the end of each day's work.

After a group of farmers has successfully terminated the lay-out and after this fact has been verified by the supervisor, each farmer receives the tools on a loan basis. The farmer is to understand that he retains the tools only after one full year of successful participation. The same procedure for loaning tools to the farmer group and subsequently to individuals within the group can be repeated for each field activity.

Spacing and Field Layout

Spacing is determined on estimates that the optimal beneficial number of mature trees on a hectare varies between 15 and 60. This, of course, depends upon the soil and the crop. Assuming possible loss to fire and to grazing, and also realizing faster results through tighter grouping, the *Acacia albida* seedlings are planted every ten meters, giving 100 trees per hectare.

There are any number of methods to stake the spacing of the fields. Any may be used as long as there is some linear order kept with a spacing of 10 m by 10 m. The spacing is necessary to ensure an even distribution of trees in order to provide the most beneficial coverage and also in order to make allowance for the possibility of future use of tractors in the field. It is suggested that the system used for this field spacing be kept as simple as possible. One possible method is the following:

1) Line A is formed with a 100 m cord; stakes are placed at each 10 meter interval (A1, A2, A3 ..... A10, designated as stake placements).
2) Line B is formed by stretching the cord at a right angle to line A. (The angle can be formed by using the 3:4:5 system, whereby two sides of the triangle are in a ratio of 3 units to 4 units with eachother, and the hypotenuse is, therefore, 5 units).
3) Line B is staked out at 10 meter intervals (B1, B2, B3, etc., designating the placement of the stakes along line B, with B1 being the same stake as A1).
4) Line C is struck from the point, A10, and stretched out 100 meters, so that it is parallel to line B (again the 3:4:5 method can be employed). It is then marked off at 10 meter intervals with C1 being the same stake as A10.
5) Lines parallel to A can now be struck by advancing the cord so that the first and last stakes are at corresponding intervals along lines B and C (line D, first line parallel to A, would have D1=B2 and D10=C2, and so on for each line).

4. The Farmer Education Component

This project does not purport to revolutionize the Sahelian farmers' methods of raising crops. The Sahelian farmer has been cultivating crops for many generations and evidently he has survived quite well. However, the project contains an educational component intended to demonstrate to the farmer how he can increase his food and fuel production by a significant margin by using simple technology based on local resources. In most cases, the techniques being introduced are already well known in parts of Chad as well as in other areas of the Sahel.

The need for this type of education is based upon the new realities facing the Sahelian farmer. With the increase in demand placed upon the land, it is very clear that arable land is fast becoming limited. The land is simply not able to regenerate itself quickly enough to meet the present demands. The recent (and continuing) drought has shown how little food reserves exist at this time. Thus, the situation demands that the Sahelian farmer makes the transition from the area-expanding system to the yield-expanding system; the same land must give a higher yearly yield, and it must also produce for more successive years without being fallowed.

The project, primarily, expects to demonstrate to the farmer that

1) he can produce more food by establishing field plantings of Acacia albida and wind breaks, and
2) benefits can be realized from proper trimming and culling of the trees in the wind-belts.

Furthermore, efforts are being made to maximize the use of the existing Acacia albida trees. Farmers are being encouraged to plant under the tree and to protect young trees. Finally, wood lots, both private and communal, are being encouraged in order to meet the future wood needs of the countryside, as well as to strengthen the rural economy.

C. The Nursery for the Acacia albida

A temporary nursery, which will function for two to three years, is constructed to supply trees for each geographic area. These nurseries also serve as a center of operations and as a training ground for local farmers.

1. Nursery Site Selection

Selection of the sites for the construction of the temporary nurseries should be made between the first week of November and the fourth week of January, thus allowing enough time to have some idea as to the number of participating farmers in the area, and to be early enough to prepare the site for timely seeding of the Acacia albida. Site selection should take the following criteria into consideration:

1) That there are a sufficient number of participating farmers to merit the construction of a temporary nursery;
2) That there is an available year-round source of water. Either a year-round well or river, with a motorized lift system, will be required. The system must operate at a daily rate of at least one liter of water per day per six pots. An inadequate supply of water for longer than three days may ruin a year's work;
3) The area should be flat, with a slight slope and drainable soil. It should be sufficiently large to accommodate the number of nursery beds required as well as a work room, storage shed, guardian's hut, potting shed, interior road, water supply, etc.;
4) There should not be a heavy tree cover although there may be one or two trees for shading certain work areas;
5) The location should be close enough to a village of sufficient size to provide an adequate labor source;
6) The supervisor should locate himself close to the nursery;
7) There will be year round access for two-wheel drive vehicles;
8) A nearby source of potting soil would be convenient.

After the site is chosen by the Forestry Service's Technical Officer and approved by the CARE representative, a written agreement for the use of the land for at least two years is obtained from the village authorities.

2. The Nursery Lay-out

As soon as the nursery site is selected and after a written agreement is finalized with the town notables, a crew of farmers will be recruited for the lay-out of the nursery. The number will be determined at the rate of 3 farmers per 10,000 pots in the nursery. These teams will be recruited locally and rotated periodically in order to give as large a segment of the populace as possible the experience of working in the nursery. It is a goal of the project that this training in new agricultural methods is a benefit to the farmers.

The lay-out design of the nursery is done by a Forestry Service technician assisted by a CARE representative, and the actual construction will be supervised by a Forestry Service technician. Nurseries should be ready for operation no later than the 4th week of January.

The general lay-out procedures are as follows:

1) The size of the nursery is determined by the number of seedlings to be raised. Space required is as follows:
   - 20 m2 per nursery bed (one bed equals 1,000 pots)
   - 100 m2 for work area and potting shed
   - 100 m2 for soil dump
   - 100 m2 for research and reserve area
   - 100 m2 for guardian's house and warehouse
   - 100 m2 for water supply and turn around
   - sufficient area for truck access roads and safe space.

   The average sized nursery for 50,000 pots is about 2,500 m2.
2) All vegetation is cleared from the area.
3) A temporary fence, strong enough to keep out cows and donkeys as well as smaller animals such as goats and rabbits, is constructed. The fence consists of five strands of barbed wire upon which chicken wire or straw mats are strung, and 2m ronier posts treated with crankcase oil. The posts are spaced 4 meters apart.
4) Pot beds of 1.2 m by 10 m are dug to a depth of 1/3 the length of the pot. Each bed should hold 1,000 pots, thus facilitating counting. The maximum width of the beds should be 1.2 m as this allows easy access to the center of the beds for transplanting and weeding purposes. The beds have an east-west orientation to minimize sun exposure on outside rows and to allow equal sunlight to all pots for equal growth. Attention is taken to keep the nursery beds

running perpendicular to the access roads to facilitate the transporting operation. One meter is allowed at either end of the beds in order to allow the pots to be advanced during pruning operations.

5) Paths of 60 to 100 cms will be left between rows for work with wheelbarrows, tending of the seedlings and erection of shade hangars.

6) Room for a few extra beds should always be allowed for unforeseen reasons. Also a section of the nursery is set aside for special research plots and seed beds.

7) An area is provided for the mixing of potting soil and the filling of pots. A straw-covered potting and rest shed is constructed next to the soil mixing area.

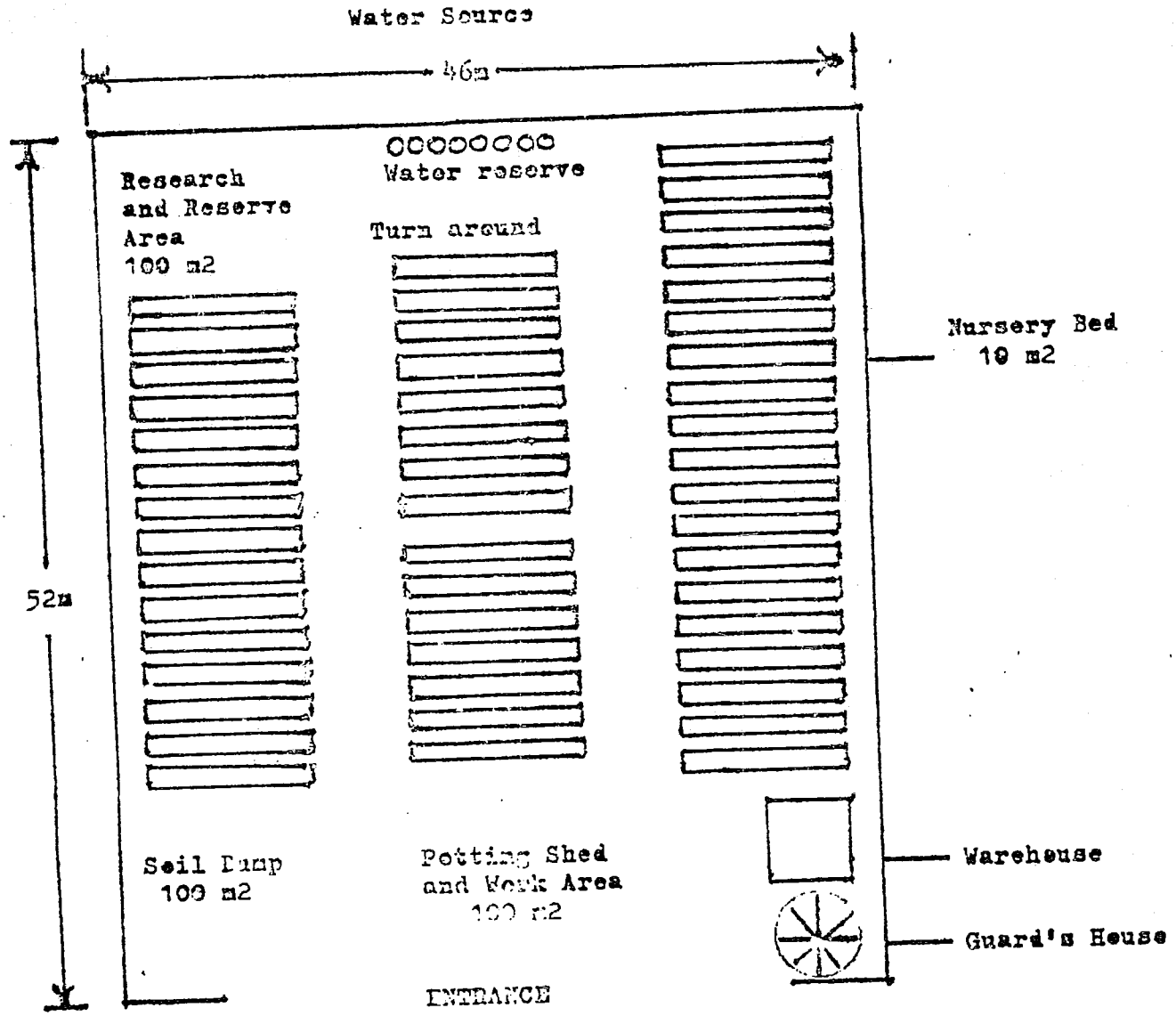
8) A large path of 5-6 meters wide is left between each row of nursery beds for easy access to trucks for the loading of the pots.

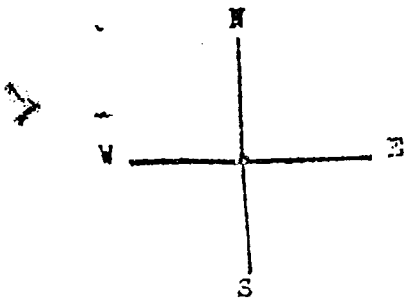
9) A storage shed and guardian's hut are built. The guardian's hut is constructed in the local fashion with local materials, and the storage shed is a prefabricated wooden structure. The tools, seeds and poisons will be kept in the storage shed. This shed must have a sturdy lock.

10) A water system with a 3½ h.p. gasoline engine pump, plastic tubing, and empty barrels (200 liters) for storage of the water, is installed. It is estimated that 5 barrels are required per 10,000 pots.

11) To economize on fencing material, an attempt should be made to build a square nursery. Please refer to the following diagram for an example of a typical nursery lay-out of 50,000 pots.

NURSERY LAY-OUT DIAGRAM





TOTAL AREA
2,392 m2

3. The Potting Mixture

Collection: The Forestry Service field technician assigned to each nursery is responsible for locating the sand and manure required for the potting soil. The delivery of the soil to the nursery begins as soon as the nursery is ready for operation, and all soil is to be delivered no later than the 4th week of February. The actual collection and delivery of the sand and manure may be done by either one of the CARE trucks or by chartered trucks. It is advisable to use chartered trucks for this as this activity can consume much of a supervisor's time. The cost of hiring a truck in Chad is about 11,000 CFA a load or 44,000 CFA a day.

The amount of sand, manure and binding agent (silt) required at each nursery site can be calculated by figuring one cubic meter of sand for each 250 pots. Manure is required at a 1:3 ratio with sand, and silt is collected at about 1:20. Because the manure and the silt particles fit into the voids between the sand particles, only the volume of sand is calculated against the number of pots.

Soil Mixture: Besides considering the fertility of the potting mix, one must be aware of its physical properties. On the one hand, the soil must be heavy enough to stick together during transport and planting operations; on the other, if there are too many fine particles in the mix, crusting and compaction are likely to result during the watering activities. The ideal soil for the nursery is 3 parts coarse sand and one part well-decomposed manure. However, this mix is subject to disintegration when the bag is opened during transplantation. Therefore, the potting soil must have some fine particles of soil as a binding agent. The fine particles can be collected from sweeping the loose dirt from beneath a tree and screeing the foreign matter out. In no case should fine particles of soil make up the major portion of the mix, nor should they be used without first mixing well with sand and manure. The mixing must be done when all components are dry. After a thorough mixing, the mix is to be watered and turned for a couple of days to germinate weed seeds as well as to obtain uniform moisture content. All soil used for Acacia albida seedlings will be ready for potting no later than the third week of March.

Filling Pots: Beginning the first week of March, the filling of the plastic pots begins. Most of the mixing of the mixture has been completed at this time. As the pots are filled, theybare transported to the beds to be placed in straight and even lines, and they are watered so that all weed seeds are germinated and the bottoms of the pots retain moisture. Once dried out, the soil in the pots is difficult to recharge with moisture.

The moist soil is packed firmly into the plastic pots but not so tightly that the sides split. The pots are filled and tamped to 1 cm from the top of the plastic bag. Overfilling or underfilling should be avoided as the former would cause the water to run off and the latter would result in the collapse of the sides of the pot. Both would eliminate the pocket designed for water catchment. After the pots are filled under the potting shed, they are transported, by wheelbarrows, to nursery beds and are placed firmly in against eachother. All pots should be filled and in place, waiting to be seeded, no later than the 1st week of April. Sloppy placement such as when the pots are leaning, rows are not respected, or the tops of the pots are not level, will mean wastage of water and loss of seedlings.

4. The Collection and Storage of Seed

Collection: The *Acacia albida* pods begin to ripen in December and continue to produce through the month of March in Chad. A mature pod is orange. It is important to collect the pods directly from the tree, where possible, or immediately after they fall to the ground, as they are grazed by animals or attacked by insects. Collection of the seeds will begin the first week of December and will continue through the fourth week of January.

A field technician takes a sample of the seed and food, to be traded for the seeds, to various villages where the *Acacia albida* exists. He solicits the villagers' help in the collection of the seeds. The field man explains that they will receive a pre-determined amount of food for each koro (kilo) of good seeds they collect. He explains that the pods are to be collected from only the healthy trees with straight boles and umbrella crowns. He further explains that only the mature (orange) pods are to be collected, and that they should be collected directly from the tree where possible, or from the ground only if they are not infested by insects. After collecting the pods, the women separate the seeds from

the pods by pounding the fruit and winnowing the pulp.

On the agreed day, a truck is sent out with food and sacks to collect the seeds. Only the uninfected seeds will be accepted. For the record, individual forms will be filled out for each exchange of food or seeds. For purposes of calculation, one kilo of seeds contains approximately 10,000 seeds, and at least 6 seeds per pot should be allowed for.

Storage: The Acacia albida seed is a hard-shelled seed and can be stored up to one year without great loss of viability. Attention must be paid to ensure that the seeds are kept free from insects. This can be done by treating the seeds with HCH and storing the sacks in a dry place, preferably off the ground. For testing of viability, see technical section on viability testing.

5. The Sowing of the Seed

All seeding of the Acacia albida will be done between the second and third week of April. The correct timing of the seeding is an important factor for a good survival rate, and must not be advanced or delayed. If the pots are seeded too early, root pruning becomes a potential problem as the tap root can develop very rapidly. On the other hand, if the pots are seeded too late, the seedlings may be too small for planting out at the correct time. Pots seeded in the middle of April give sturdy stock which normally does not require root pruning.

Germination Inducement Techniques: For any nursery stock, it is desirable to have an even growth. With the Acacia albida, this is very difficult to obtain when seeding directly into the pots, as the germination rates vary greatly in different seeds. Nevertheless, an attempt can be made to have relatively even growth by applying germination inducement techniques. Some available methods to induce rapid germination are heat and cold stratification and scarification. The best results, although the most costly in terms of man-hours, are experienced with scarification. Scarification is the process by which the hard coat of the Acacia albida is nicked or otherwise penetrated in order to allow penetration of the necessary moisture that triggers the germination. In nicking the coat, care should be taken not to cut the root section of the seed, nor should too much of the coat be cut. The scarification of seeds begins immediately before the seeding of the pots, as a scarified seed does not tolerate storage.

The second possible method of catalyzing germination is alternate soakings in hot and cold water. This treatment, known as stratification, should be practiced in order to obtain correct sequence, temperature and timing.

Before pre-germination techniques are applied, the bad seeds are separated out by submerging the seeds in water. The rotten seeds will float.

The Sowing of Pots: As a rule, a small seed is planted at a depth of three times its largest thickness, and placed in a flat, horizontal position. The *Acacia albida* will be planted three seeds to a pot (thinned later) and at a depth of 2 cm (knuckle depth). Pots are saturated with water before seeding operations. The scarified seeds are soaked overnight in water. All seeding will be completed by the third week of April.

6. The Transplanting of Seedlings

Sometimes, for one reason, or another, there is a poor take from the first sowing. If the seeding schedule is limited, as is the case with the *Acacia albida*, the delay means poor nursery stock. One method to ensure against this is to sow seed beds concurrently with the pots. If there are a number of empty pots anywhere in the nursery, they can be filled with seedlings from the seed bed. The procedure for transplanting the young stock is explained in the technical appendix.

7. The Regular Control of Nursery Stock

Watering: From the first nursery operation to the last, correct watering is the main concern of the nurseryman. The potting soil is well watered before the pots are filled. The filled pots are kep moist one week before seeding;this is to germinate weed seeds. Newly sown pots are watered at least three times a day as follows: once in the morning, once at noon before the beds are shaded, and once in the evening. The last watering must be very thorough. This schedule is continued until the hardening-off of the seedlings begins. The primary concern during all watering operations is that the soil in the pot remains moist. Once the soil at the bottom of the pot dries, it is relatively difficult to remoisten it again.

Hardening-off conditions the seedlings for the shock of planting out. Four weeks before the anticipated pre-positioning begins, the amount of watering is reduced to twice a day. One week later it is reduced to once a day and after yet a further week to once every two days until four days before pre-positioning. At this point, the pots are watered heavily several times a day in order to ensure a good reservoir of moisture in the pots during the shock period of transporting, pre-positioning and planting-out.

Once the pots are pre-positioned in the field, they should be watered as often as possible. A good moisture reserve gives the planted-out seedlings a margin against the shock, and the soil does not crumble away from the root system as easily as dried and caked soil. Water, personnel and equipment requirements for the watering operation in the nursery may be calculated on the following basis: one liter of water is sufficient for 6 plants per day. The water lift system must be capable of easily delivering twice the amount of water required. One man with two 18 liter watering cans waters 7,000 seedlings three times a day (if the water source is conveniently situated). Enough water drums are provided to furnish one day's water requirements. The last operation of every evening is to fill the water barrels for the first watering of the following morning.

Surface-Scratching and Mulching: A top crust generally forms on the topsoil of the pots. Before the crust becomes impervious to water and air, it must be broken. This entails a cultivation of each pot. This operation is a heavy time consumer and can cause a serious labor bottleneck if men are tied up with it when other operations demand attention.

To minimize crusting, a top dressing of mulch can be applied to the pots. A very good mulching material is millet chaff. The chaff is watered for one week before being applied, in order to germinate any seeds and to give it body. The pots are dressed with the mulch one week after the germination of the tree seeds. Several conscientious mulchings in the nursery give the topsoil good tilth and allows for moisture retention during the critical periods of pre-positioning and planting-out.

Shading: Shading is important in the months of April and May in order to protect the seedlings from the intense heat. Shading is allowed the seedlings for two to three weeks after germination. The beds are shaded throughout the hot part of the day during the first week. The length of

time in the shade should be lessened gradually until they are shaded only during the noon break. The shade should be left during the work break for the second week. For the third week, the shading is removed altogether if there is no damage and if the development of the seedlings is even.

The hangars can be of several types. A convenient hangar is made from a strip of straw matting laid the length of the bed. This matting is 5 to 10 cms wider than the rows and it is supported by a framework of wooden poles and forked sticks. The framework is constructed in such a way that the matting is 40 cm off the top of the pots. The length of the matting is no longer than can be conveniently rolled up.

Weeding: Weeds are a nuisance that can be partially eliminated in pre-sowing waterings. Prior to seeding, all germinated weeds must be cleaned from the pots. Weeding then becomes a regular nursery activity. In no case should the pots, beds or rows become infested with large weeds.

Insect Control: Termites, ants, caterpillars and rats can be harmful in a nursery. Snakes and scorpions are attracted to nurseries because of the frogs and insects. Thus, it is prudent to give the pot beds a light spray of Endrine before placing the pots in the beds. Use one half of the normal dose and spray in the evening after watering. There is always a danger of the poison being blown or carried to the water source. The effective life of endrine is short and the treatment may have to be repeated again during the work year, if there is a termite attack.

While endrine is good for ants and termites, HCH is used against caterpillars. Whereas the caterpillar problem may not be great in the nursery, a light coating of HCH affords the seedling some protection during its first few weeks in the field.

It is essential to be extremely cautious with all poisons. Not only are both of the above quite strong, they are also used indiscriminately by some farmers for such purposes as killing fish and wildlife. Unfortunately, fish swim in the same water that the farmers and their stock drink. Therefore, poisons must be stored in a secure place, away from the food, and they should be used only by authorized personnel.

Pruning: Experience has shown that root pruning of the *Acacia albida* is best avoided. For one thing, any time consuming activity which can be avoided without hurting the development of the plant should be avoided. In cases where all other factors are equal, non-pruned seedlings compare favorably in take and development with pruned stock. Secondly, if the sowing date and good watering practices are respected, the tap root will not push out of the bottom of the pot. Under natural conditions, the taproot would quickly penetrate the bottom of the pot, but the surplus moisture provided by good watering allows the development of a spreading root system within the pot.

However, the seedlings must be watched closely for the first signs of roots growing through the pots. Vigilance is especially important during hardening-off, when there is stress placed on the water supply. Larger seedlings must be carefully lifted out to check for exterior root development. If there are signs of root penetration, then the whole bed should be root pruned. The extra meter at one end of the bed is dug out to make a natural continuation of the bed. One row is pruned and advanced, at a time. Each pot is carefully tilted and a sharp knife inserted under it; this knife neatly cuts the root and the pot is free to be moved. If the protruding root is sunk well into the ground, then the seedling should be top pruned to the height of the pot.

D. Picket Procurement and Treatment

Pickets and stakes are used for lay-out and fencing operations. The pickets are to be 70 cm long, 3 cm in diameter at the thick end, and straight. The stakes are slightly shorter. All of the wood that is collected for use in fencing is to be treated.

The cutting of the wood must be controlled in one way or another. Even though wood is a locally available resource, the harvesting of pickets must not be a license for uncontrolled cutting of the existing woodlands. On the other hand, if the wood is taken from the prunings of trees or from the smaller shoots of a recoppicing stump, the procurement becomes a wood-stand improvement process.

The wood harvested for fencing is subject to attack from termites and to decay-causing fungi. An effective remedy against both is treatment in a hot mixture of crankcase oil and endrine. Where possible, the treatment is done at a central site with locally hired labor. It is an operation which can be dangerous if not well supervised.

Several local species are termite resistant. The Anogeissus leiocarpus and the Guiera senegalensis, both of the Combretaceae family, are fairly resistant to termite attack. However, they should still be treated.

The Ziziphus genus contains species with hardy wood that produces straight shoots from recoppicing stumps. If all but the strongest are taken from a group, straight pickets are procured and the one shoot is released for faster growth. In the treatment of Ziziphus, as in most other species, the bark should be removed first. By removing the bark, not only does the preservative and poison sink in more deeply, but aeration is improved, which naturally helps against decay.

Five pickets will be required for each picket-type fence. The picket will be approximately 80 cm long and 3 cm wide, and strong enough to be hammered into moist soil. There are three methods for their collection:

- One is simply to offer the people in various villages rations of food for a certain quantity of pickets. This is quick and easy, but there is the possibility that they will cut down entire trees.

- A second method is to form teams of workers for the pruning of trees under a controlled process. The prunings would provide the necessary pickets and, at the same time, improve the natural stand of timber in the area. This would have the disadvantage of being costly and labor intensive.

- A third method, and possibly the best, is to contract the gathering of pickets out to the Forestry Service, who are making regular prunings of their tree plantations and cutting fire lines.

Whichever method, or combination of methods, is used, the collection of pickets should be one of the first operations to begin early. The collection should begin no later than the first week of November.

The treatment process is as follows:

1) All potential picket material (strong and straight pickets at least 80 cm long and 3 cm thick) are debarbed, cut to length, pointed and wrapped into bundles of 20.
2) The bundles are dried for one week in the shade.
3) The dried bundles are plunged into a heated solution of endrine and crankcase oil, for 15 minutes. The endrine makes up 3% of the solution.
4) The bundles are then stacked at the side of an access road in preparation for their transportation to the fields.

The following precautions are to be followed during treatment:

1) Treatment is not to take place where wind or water can carry the solution to a body of water.
2) The solution is not to be left unguarded.
3) The work area is to be limited, and all animals and unauthorized personnel are to be kept away.
4) The nursery supervisor is to be present each time endrine is used. The endrine is locked away after work.
5) The treating vessel is to be securely positioned to avoid being tipped over. The vessel should not be any higher than 60 cm, and should be 60 cm in diameter. (A 55 gallon drum cut into two parts would make two perfect vessels).
6) Open flame should be avoided. Charcoal should be used.
7) The work area is to be open and ventilated.

The shorter pickets will be used for staking. This is a dry season activity and the ground can be quite hard. The stakes and pickets are cut at a ratio of one to five. The stakes are treated first and transported to the village as soon as farmers inscribe themselves into the project. The stakes will be stored close to the tool shed and individual farmers can collect them with the staking tools.

E. Pre-Positioning and Planting-Out of the Acacia albida

1. The Timing

A tree, as any living thing, goes through a shock period when it is transported and planted into a different soil. Although the Acacia albida has a relatively fast-growing tap root, it does take considerable time for this root to reach the permanent moisture table. During the period of shock, adjustment and establishment, the root system requires an adequate supply of moisture.

In the Sahel, there are generally six weeks within which rainfall is reliable and adequate. Before the middle of July, heavy rains can be followed by weeks of drought. After the end of August, the rains can quickly come to a halt, and the ground would dry up before the roots had had time to get well established. Thus, July 15 is the target date for the commencement of the planting-out operation. All stock is pre-positioned in the field one week in advance, and all planting is finished during the first week of August.

2. The Pre-Positioning Operations

Pre-positioning begins in May with the submission of the pre-positioning reports and maps. Each field supervisor compiles a full list of the farmers in his area, a map of each groupment of fields, and the number of seedlings required per area. The supervisors pay special attention to the possible effects of the rains upon the access roads. Those fields with swampy access are served first or have special four-wheel drive vehicles reserved for seedling delivery.

The seedlings themselves are well-watered and well-tended one week before pre-positioning begins. The empty pots are culled from the beds and the largest stock is transported to an area accessible for loading. (It would be inconvenient, at this time, to have a large number of small seedlings requiring special care or to have a large number of pots requiring root pruning).

From the nursery, the pots are pre-positioned a field holding nursery. The time-frame for the transporting of the pots is fixed by two factors: On the one hand it is best to leave the seedlings in the regular nursery for as long as possible, while on the other, if the pots are moved too late, the roads are often flooded or a transport bottleneck develops.

The size and location of the field holding nurseries are determined by their accessibility to roads, proximity to planting areas, and availability of water. The holding nurseries with the greatest potential for being cut off are served first. A shady tree which is close to a natural catchment basin is the desired spot. A small rain catchment basin is dug, from which the seedlings will be watered during the holding period. Thorny branches are cut and placed around the trees as protection. Generally, in the areas farthest away from the village, the farmers will have moved out there to tend their fields. One of the participating farmers is assigned to tend the holding nursery.

The role of all field staff during this time-frame is to make periodic checks on the seedlings and the soil condition. He must concentrate on encouraging the farmers to be vigilant in caring for the holding nurseries and to work on preparing the planting sites.

3. Planting-Out

Planting-out operations begin with the distribution of tools in mid-June. At the distribution meeting, the field team demonstrates the proper method of preparing the planting site as well as the correct tree-planting procedure. The farmers are to understand that the tools are only on loan until they have successfully completed a one-year trial period. In order to meet the standards required, a minimum survival rate is set; thus, the farmers are encouraged to follow proper and prudent procedures throughout the planting, cleaning, and protection operations. They are to understand that, if at any time, the survival standard is not met, they risk losing their monthly food rations and their tools. It is vital that the farmers understand that the responsibility for planting and protecting their trees rests entirely with them.

In preparing the planting site, the farmer is encouraged to form a catchment basin at the site of each stake, and then to dig the hole to the depth of the soil moisture. The hole is refilled with top soil. This preparatory step can make the difference between a loss and the development of a large one-year old tree. (It is noted that the hole is not to be left open).

When the rains show signs of being reliable, and when the soil moisture reaches the depth of two pot lengths, planting-out operations begin. This is generally around the middle of July. If, in any way, there is

not enough rain by the beginning of the last week of July, planting-out operations must begin in any case. When seedlings are planted-out this late, a special procedure is required. It is very time-consuming and should only be used when the normal schedule cannot be followed or when seedlings are replaced in the month of September. This technique is described after the description of normal planting procedures.

Transport of Pots to Individual Fields: Although it is best if the farmer transports his own seedlings to the field, it may prove necessary to hire local labor to transport the trees to the various fields by wheelbarrow. If this is the case, two men should be hired to operate each wheelbarrow, one pushing and one pulling. As each wheelbarrow has a capacity of 15-20 pots, it is estimated that one wheelbarrow per 1,000 pots should be available at this critical time. There are of course other methods to transport the pots which may also be used. (See photograph of Chadian girl carrying *Acacia albida* tree).

Planting Technique: A demonstration of the planting techniques will be done, in both group meetings and on individual farms, by the field supervisor, as soon as the word has been given to begin planting. The farmer will be instructed that:

1) An area of about one square meter be cleaned of all vegetation (excepting the farmer's crops).
2) A hole be dug immediately before planting to a depth of 1½ pot lengths. Holes are not to be pre-dug, as this results in evaporation of soil moisture. Top soil is filled back into the hole until the hole is just over a pot length.
3) A "cookie" is sliced from the bottom of the pot, and any exposed or curled root sections are neatly pruned.
4) Supporting the open bottom of the pot, the planter carefully places the pot into the hole in such a way that the collar of the plant is two centimeters below the level of the ground. (The collar is at the soil level of the pot).
5) The hole is partially filled to support the pot, and the pot is sliced up the side in order to facilitate the removal of the plastic.
6) Soil is then carefully filled in around the pot, as the bag is lifted off up to the collar.
7) The loose soil is then "heeled in" to add stability and eliminate air pockets.

8) The stake is then replaced next to the tree.

Great care should be taken to avoid disturbing the root network and to ensure that the tree is planted to the correct depth. One supervisor should control the planting of 5 hectares per day to ensure that correct techniques are applied, since the survival rate depends greatly upon correct planting.

4. Emergency Planting Technique

When the rains have come late, or when dead trees are being replaced for one reason or another in September, or when a conscientious farmer desires to ensure high take and good development, a special planting process can be used. It is both energy and time-consuming. If good normal procedures are followed and if rainfall is normal, good take and development of the Acacia albida does not require the extra work of this process.

The special process is as follows: When the soil is dry or drying, a hole is dug and filled with water and left to soak overnight. The next morning, the deeper soil, which is moistened from the soaking, is dug from the hole and replaced with top soil. The hole is again filled and then brought up to the length of the planting-pot. The seedling is planted and watered. In effect, this procedure creates a moist, rich and soft channel into which the tap root can more easily and more rapidly penetrate. A catchment basin should be formed, and the seedling should be watered in such a way as to allow the moisture to sink to the bottom of the disturbed soil.

5. Direct Seeding

The direct-seeding process offers great potential in the propagation of the Acacia albida. It is indigenous to the Sahel, and it follows that most existing trees were germinated from non-cultured stock. However, there are some initial problems to overcome before the direct-seeding process can be used in all the sectors of the project.

Experience has shown that the enemies of the young Acacia albida seedlings are pioneer grasses, fire, the farmers' hoes, and grazing animals. On the other hand, the tap roots of the naturally propagated stock develop much more rapidly than the nursery stock which tends to produce more lateral roots. Furthermore, the cost of the nursery and the transplanting

operation would be greatly reduced by direct seeding, if the proper method were found which would fit the policies of the project. The major policy which would conflict with present methods of direct-seeding is the non-disruption of normal land-use patterns. The most successful, directly-seeded Acacia species plantations, to date, have been in areas kept under strict control for a number of years and where cultivation and grazing is eliminated from these areas.

The major advantages that potted stock have over direct-seeding are:

1) The potted stock system provides a tree that is easier for the farmer to see.
2) The transplanting of the potted stock (if properly done) is a one-step operation, whereas the direct-seeding method requires subsequent visits for thinning.
3) The spacing in a potted stock plantation is more even because of the one seedling to one stake practice.

Correct seeding procedures should be exaggerated in the beginning to ensure maximum take. The procedures can be simplified later as certain steps prove themselves to be superfluous. A very good procedure for initial direct seeding is as follows:

1) Clear an area of 4 m2 around the stake.
2) Form a water catchment basin around the stake in such a way that all water drains toward the stake.
3) Dig a hole 40 cm deep with a soil auger or shovel and refill it with top soil.
4) Stratify seeds using the alternate boiling-cooling or alternate soaking-drying process, and plant at three to six per hole, at a depth of 2 cm.
5) Thin the plants back to the strongest two after the cotyledons fall from the seedlings (thinning must be done carefully so as not to disturb the root systems of the good stock).
6) Thin to the strongest sapling before the termination of the rains.
7) Periodic weeding must be done to eliminate competition from pioneer grasses (or seed in a grain field) and an area of three meters should be cleared around the seedling to protect it from fire.

F. Post-Planting Operations

It is not enough to simply plant the tree. In the Sahel, more than in other climatic areas of the world, there is a multitude of forces working against the survival of a tree. Some of the most noticeable are: grazing by animals, invasion by insects, burning by fire, desiccation by drought and damage from the farmer's hoe. The margin for success is smaller. It is recognized that there will always be a certain percentage of mortality among artificially regenerated seedlings, but it is the aim of this project to do all possible to combat these destructive elements in order to attain the highest possible survival rate. The farmer, himself, must realize that he is to manage and protect his trees for at least two years.

1. The Cleaning or 'Releasing' Operation

If the seedlings are not planted-out in millet fields which are systematically cleaned of wild grasses, the trees must be released of competition from the grasses by weeding. A circle around the seedling, four meters in diameter, is cleared of all annual vegetation (except, of course, the grain crops), and a rain-water catchment basin is formed. This operation is done as soon as the seedlings are planted-out, and must be systematically done throughout the wet season.

When the crops are in, the millet stalks are also removed from the immediate area of the *Acacia albida* sapling. The final cleaning is done in all fields before the fields are burned; the fields are often burned immediately after the crop has been harvested, and every precaution must be taken to ensure protection of the trees from fire.

For the fields which are not cropped in grain, one pre-cleaning might be done as soon as the wild grasses germinate in order that the site receives the full benefit of the rainfall. With the stake as the middle, a circle, 4 meters in diameter, is described, and a rain-water catchment is formed. However, the farmer should not be encouraged to clean his field entirely. From the standpoint of encouraging good soil conservation practices, a 'dirty' field is the best field. Soil conservation techniques are explained in latter sections.

2. Fencing

An important pre-requisite of managing stands of field trees in the Sahelian region is some form of protection for the young trees from the browsing livestock. A fence of one kind or another is needed. It is common practice to open fields to browsing animals immediately after the harvest in October or November. Therefore, the fence should be in place as soon as the harvest is in.

Although there are several types of fencing which can be used, this project requires certain criteria in selecting the kind of fence to be used:

1) Since this is a field-tree project which integrates itself into the normal land-use cycles, the fencing should not disrupt traditional land-use patterns. A fence encircling a whole field would do this and should normally be avoided. Not only would most fences be broken by animals, but the local farmers would complain when the paths to water wells or to markets are broken. Furthermore, the manure of the grazing animals is a well-appreciated commodity among farmers, for the fertilization of his grain fields. Therefore, every tree is separately fenced, except in experimental or demonstration plots.
2) The Acacia albida is not shade tolerant as a sapling. The fence, therefore, should be wide and low, if all other factors are equal. (Some pre-fabricated fences are not wide but they do not cast a very big shadow).
3) The fence should be removable or disposable, in order to allow the farmer to crop the land the following year or to clean thoroughly around the Acacia albida.
4) The fence must be made mostly from local materials. If there is to be a multiplier-effect resulting from the project, whereby other farmers follow the examples of the participating farmers, imported materials would be a large obstacle.
5) A good fence in the Acacia albida project is not necessarily one which is designed to prevent access but one which demarcates the sapling and discourages trampling and browsing.
6) Finally, and most importantly, the most difficult part of the fencing operation is not the technical aspect. The key to successful protection is the motivation of the farmer himself. He must accept the responsibility from the very beginning and be encouraged to keep the initiative.

The types of fencing are variable. Here are several, with comments on the pros and cons of each:

1) Basic thorn fence: Thorns are traditionally used in the fencing of farmland and gardens. They are generally good for a year and are effective when applied correctly. The disadvantage to thorns is their susceptibility to termites, the amount of work required to gather thorns for every field-tree, the high kindling point, and the timing. If the thorns are sprayed, termites are no problem. The high kindling temperature of the larger thorn branches is more likely to scorch the seedling than a grass fire. Therefore, the cleaning must be thorough and wide enough to lessen the chance of the fence taking fire. The farmers must accept the responsibility for erecting the fences as soon as possible after the harvest is in.

   The thorns are supported by local pickets and cord. Both the pickets and the cord are pre-treated with endrine. The pickets are 80 cm high and 3 cm thick. Four pickets are placed in a square around each sapling, 1.5 m apart from one another. The clearing should be such that there is bare ground for at least one meter around the outside of the square. The stake used to mark the sapling is left close to the sapling to continue marking it. The pickets are placed into the ground at planting time as the ground is then moist; after the rains have stopped, the ground becomes very hard and difficult to penetrate with a picket. The The pickets are placed at a slight angle away from the plant. The cord is wrapped around all four pickets at two-thirds the height of the shortest stake. Slender thorn branches are laid against the cord and are then wrapped tightly with a second coil of cord.

2) Millet Stalk Fence: This type of fence employs the same picket formation as the picket/thorny bush fence, but will use millet stalk for the fencing material. This type of fencing will be used where thorny bushes are scarce.

   As millet stalks are readily attacked by termites, these fences must be treated immediately with endrine. It is also possible, and advisable, to use the Guerra senegalensis bush for fencing material, in the same manner in which the millet stalks are employed, since it is termite resistant.

3) Prefabricated Fences Using Locally-Available Materials: Several types of prefabricated fences are possible. These could be made of thin branches tied together with strips of bark or grasses, dried grasses

woven together (Andropogen gayanus), etc. The advantages of the pre-fabricated fences are many:

- They can be made by the participating farmers during the slack period of December through March. The fence building would be a part of his obligation, and he would have to make 50 a month to maintain the ration of food level. This would take pressure off the farmer during the harvest period and would also keep him interested and participating between the staking out of the fields.
- Eliminate the chore of collecting thorny branches.
- Easy removal of fence for cleaning inside and for repair.
- Timely placement of the fence after harvest.

This type of fence would be attached to the ground with three pickets. The unit would be treated with endrine twice each year.

3. Insect Control

The Acacia albida is prone to attack by caterpillars. This attack occurs during the months of September and October, and may continue throughout the year. While the insects may completely defoliate the young seedling several times before the end of the rainy season, there is no record in the project of the attack being directly responsible for the death of a seedling. Many experts have stated that it is a normal part of the cycle.

On the other hand, there was a serious attack on Acacia albida trees in the Zinder region of the Niger Republic in 1971 and 1972. It is not known whether the caterpillar was similar to the species found in Chad. There have been no reports of further attacks from Niger. In fact, foresters in Niger report normal seasonal attacks which make no noticeable difference to the survival rate and development of the tree.

However, precautions should be taken. HCH powder is used for this. It is a dangerous poison with a long half life and should be used with discrimination and caution. A prophylactic treatment should be done in the nursery prior to pre-positioning. If attacks persist, treatments can be carried out in fallow fields as needed, or in millet fields after they are cleared of grain. These treatments are to be carried out by authorized personnel only.

Termites are also a potential problem. Termites attack untreated fencing material. In the nursery, they attack the plastic pots. The standard treatment for termites in the project is endrine, used at half the normal

strength. For treating pickets, it is mixed with oil (see picket treatment). In the field, it is sprayed onto the seedlings and fencing as soon as the crops are off the field.

Endrine is a highly toxic poison. As in its use in the nursery and in the picket treatment process, the field sprayings must be done under supervision.

4. The Surveillance Operation

In order to deter damage by insects, animals, fire, etc., as well as to guarantee that the various operations of the program are implemented properly, there will be periodic inspections of fields by the field technicians and supervisors. The field visits are the main responsibility of the Forestry Service field cadre and the village supervisors. They will carry out regular inspections of trees, as described below, and count the number of survivors. It should be noted that some trees which appear wilted and dead may, in fact, still have an active root system and be only temporarily dormant. One method to test whether or not a questionable is alive is to scratch the base of the stem. If it is green under the bark, the tree is still alive.

During the course of one year, there will be five formal inspections, and the results will be sent in report form to the central office.

1) Field lay-out survey: After the fields are staked out, an inspection will be made of the lay-out of the farms. The number of pickets will be counted and reported to the central office by the third week of May, so that the positioning of pickets and pots may be properly controlled.
2) Planting survey: Immediately after planting-out, a survey will be made of the trees planted. This should be finished before the third week of August. This inspection is to ensure that the trees have been planted correctly.
3) Releasing survey: The third survey will be made after the first releasing in September. As well as a control for proper releasing of trees, this survey would serve to ensure that the pickets are properly fixed in the ground and also control for insect infestation.
4) Fencing survey: The fourth survey will be made after the fences are constructed. This survey will also serve for control of the fire lines around each tree, this being the time of year for field fires.

5) Beating-up survey: The fifth survey will be made during the first and second weeks of April, and will be for the counting of mortalities only. This report will be used for the delivery of replacement trees.

5. The Replacement Operation (Beating-Up)

Although it is recognized that the replacement of mortalities during the second and third year of planting is not accepted as practical silvicultural technique, it will be applied in the case of this program, since the final goal of the project is soil restoration as well as reforestation. For the most effective restoration of soils with the *Acacia albida* tree, there should be complete and equal coverage of the area. It is not so important as to how many trees there are on a hectare, but rather how they are distributed. The target for this project is to have an equal distribution of 50 or more healthy and protected trees after the second year. Reports show (Giffard - Les Possibilités de Reboisement en *Acacia albida* au Senegal - 1964) that with 10 - 20 mature trees per hectare, continual cultivation without a fallow is possible.

Therefore, in order for a farmer to retain his tools and food rations after the first year of planting, the farmer will have to maintain a 60% survival rate or replant the following year.

III. Windbreaks and Village Wood Sources

A. Needs for Village Wood Supply

Woody perennials are an integral part of everyday rural life; almost all of the fuel is wood or charcoal, all shelter includes some form of forestry product, hand tools and house utensils are primarily made of wood, thorn-producing wood is harvested as fencing, perennials provide an important source of animal forage, and standing perennials give windbreak protection to man, animal and soil. While the demand for wood products is increasing, the supply is rapidly decreasing.

As wood is cleared for farmland, fuel and shelter, perennial vegetative cover is lost. Perennials protect man, animal and soil against the harsh elements of the Sahel. The gusty winds cause damage to crops both directly and indirectly by uprooting or breaking plants, eroding top soil (see saltation in appendix), and increasing trans-evaporation in plants or evaporation of soil moisture. In order to best use his energy, man too needs relief from climatic extremes. In the Sahel where the temperature mounts to over 120°, body heat is dissipated through perspiration, a process which requires body energy. In temperate climates, averaging 70°F, body heat is passed by induction and relatively little energy is required.

In the search for fuel, women often compete with the men for the manure in the grain fields. The reason for this is the lack of wood within walking distance of the village. The wood problem was solved traditionally by the periodic movement of the farmers from one planting site to another. For a variety of reasons which include the lack of new arable land or the need to keep children in school, farmers are staying longer or permanently in one place. Furthermore, the rural areas around the population centers supply the fuel and construction wood for the cities. While the commercialization of wood products strengthens the rural economy, very few provisions are being made to ensure a future source of wood. Thus, while the Acacia albida tree aids the soil to retain fertility for longer periods of time, a farmer's access to wood products becomes a prime factor in his stabilization.

To meet the above-mentioned needs, multi-purpose windbreaks and shelter-belts are planted as a complement to the Acacia albida. Windbreaks are normally made up of a double row of trees on the windward side of the field, which protects the immediate area. A shelter belt is a larger

plantation of trees, usually with a definite planting pattern, with the objective of levelling climatic conditions for a more extensive area. A shelter belt or windbreak, properly managed through selective cutting and culling, realizes a sustained yield of wood products without losing the windbreaking and shade benefits.

For the purpose of this project, and convenience of terminology, a shelter belt and a village firewood supply will be considered the same, and will be referred to as village wood sources.

B. Site Selection

Villages have generally been the basic unit for village wood plantations. However, individual farmers will be encouraged to participate in this activity. One farmer in Mai-Lao planted 5,000 Neem trees in 1975 and 1976, and many of the trees are three meters or more after only one year. He can presently harvest kindling and will soon be able to cut larger branches for firewood and construction wood.

This tree-planting also serves to provide shade and strengthen the village's economy.

During the relatively slack month of February, the Forestry Service technical officer and field technician survey the chiefs in those villages participating in the *Acacia albida* project on their responsiveness to the planting of windbreaks and village firewood sources. If the response is positive, a meeting of the villagers will be arranged to discuss the benefits of windbreaks and village firewood stands. At this time, candidates will be signed up for windbreaks, and sites will be selected for communal or individual plantings.

C. Field Operations

Immediately after candidates for the windbreaks are selected and the site is chosen for the village firewood stand, lay-out may begin. This operation will be supervised by the Forestry Service field technician.

a) Windbreak: For the windbreak, two to four rows of stakes will be spaced at 4 meter distances on the windward side.

b) Village Firewood Stands - Shelter Belts: The lay-out for the village firewood source will be exactly the same as that for the *Acacia albida* fields, but with spacing every 4 meters rather than every 10 meters.

All sites for the planting of wind breaks and village firewood sources will be selected and staked out by the 4th week of February. The villagers are then told that the trees will be delivered the first two weeks of July. The field technician will send to the head office, by the second week of March, a complete list of candidates for the windbreaks, a list of all sites for the planting of village firewood sources, and the requested number of trees needed for planting these.

Planting: Based upon the list provided by the field supervisor in March, the trees will be transported to their respective areas during the first and second weeks of July. They will be deposited under a large tree, and one person will be put in charge of watering them and keeping the goats away until the trees are planted-out.

Although the prime planting time is at the beginning of the rainy season and would, therefore, correspond to the prime planting time of the *Acacia albida*, the planting of the *Neems* or other species should in no way delay the planting of the *Acacia albida* trees. The *Acacia albida* is the priority tree. Planting will follow the same procedures as those for the *Acacia albida*.

Releasing: Between the third week of August and the second week of September, a circle with a diameter of 4 meters should be cleaned of vegetation around each tree. Cultivation and catchment basin formation will be done at the same time.

Leaf Stripping or Pruning: Along with the releasing operations, the large leafed trees will be stripped or pruned of most of their leaves in order to reduce transpiration and to train the trees. All leaves and stems, except the terminal leaves, will be carefully broken off. Care must be taken not to rip the bark of the tender seedling while doing this. Pruning operations will become a regular activity of the field supervisors and agents. Not only does prudent and correct pruning improve a stand, but it demonstrates the benefits of year-round management to the farmers. Pruning shears are provided to field supervisors.

Fencing: Windbreak trees, planted around farms, will best be protected by individual fencing as described for the *Acacia albida* fencing. One additional type, fencing made from mud bricks, may be used. Village firewood sources, planted in larger stands, may best be protected by perimeter fencing. This technique must be used taking local land-use patterns into account.

Guarding: For the village firewood stands, a guard is employed to chase away animals, water as necessary, repair fencing, and do periodic releasings. A guard is especially important when using perimeter fencing, as one hole gives complete access to foraging animals.

D. Tree Species for Windbreaks and Wood Stands

Neem (Azadirachta indica): This is the principal tree for village wood plantations. It is fast growing, and the farmers know it to be a good shade tree. The older growth wood is good firewood and the younger wood can be used for kindling (even though it smokes when green). The leaves provide a forage that is often preferred over annuals.

This is an exotic species native to India. It was introduced to Nigeria in the 1920s and has enjoyed popular use as a shade tree. In India and the Mid-East, it is used in the construction trade. Some work is currently being done in several centers in the Sahel, researching the possibility of wider uses for the tree. This species could become a more effective source of raw material through multi-use.

The sequence of nursery work for the Neem is the same as that for the Acacia albida. The time frame and the seed storage and preparation are different. Neems can be transplanted bare-rooted or in pots. The bare-root stock is seeded in November, and the potted stock in January.

The seeds have a soft coat and are perishable. They can be stored for no more than two weeks with assurance that the majority will hold their viability. The dried seeds are soaked in water the night before seeding. For best results, they are seeded lying flat at a depth of 2 cm.

The Neems and other exotics for the project will be raised in the Central Nursery of the Forestry Service. The seedlings will then be pre-positioned to the fields or field nurseries as conditions dictate. In transporting the seedlings from the Central Nursery, consideration must be taken into account that a possible transport bottleneck can occur because of the long distances which the seedlings must travel.

Dalbergia Sissoo: This species is not seen as often as the Neem. However, it has been planted in forestry reserves as well as in shelter-belts and shade-tree plantings.

Cassia Siamea: This species is much the same as the Dalbergia except that the heart-wood is softer.

Acacia scorpioides: There are two varieties of this species which would be very interesting in the exploitation of marginal land. The variety nilotica grows in marshy areas and can be a very fast source of high quality fuel and construction wood. The variety adansonili is found on higher land but it is similar to the nilotica in quality. The species is native to the Sahel, and it has long been known as being a source of tannin as well as of quality wood.

IV. Live Fencing - Deflection Barriers

A. The Need for Fencing in the Sahel

Land-use control is a rare thing in the Sahel. The right of the farmer to control the use of his farmland is generally practiced only during the rainy season. Under normal land-use patterns, the fields are burned off and then browsed clean by foraging animals.

During the wet season, grain fields bordering paths and animal trails are often fenced with thorns. This barrier is designed to screen or deflect animals rather than to prevent them from entering completely. In most cases the animals are guarded by a herder, and the barrier complements his vigilance.

During the dry season, the gardens are enclosed in some form of fence. Again, this is generally a thorny barrier. Imported materials are too expensive to be covered by profits from the small enterprise of a rural garden.

While generally considered as a long-range project, there have been at least two large-scale efforts in the Sahel to fence land off from normal dry season patterns of usage. (See appendix on results of land-use control). There are many socio-economic problems to be faced when disrupting traditional land-use patterns in this fashion. However, experience has shown that a year-round management plan is a very productive alternative to current situations found in some areas, where land is over-grazed and burnt to such a degree that it takes many years to regenerate itself.

The farmer generally cuts thorn trees down or lops off limbs from the larger ones, in order to find the thorns for his fence. Not only is the procurement of the thorns an energy-consuming activity, it is a practice which denudes the land of trees and bushes. The farmer is now being presented with a plan to eventually establish live fences which will first complement and then replace his traditional fences. In turn, these live plants will be partially protected from grazing animals by the dead fencing.

B. The Species: Uses and Establishment

The type of fencing chosen depends upon the area. Generally, a live fence should be woody and should not cast too much shade. Local farmers are often a source of information on the species which can be used, but even this generally reliable source is weak because of the paucity of live fences in the Sahel.

Commiphora africana: The strongest argument for the Commiphora africana is that it is one of the few woody species used by Sahelian farmers in traditional live-fencing. Its biggest drawback is its scarcity.

The Commiphora africana has straight branches which terminate in a thorn. When the plant is top-pruned, the bottom branches enclose and form a physically strong as well as a potentially painful barrier.

It is planted from cuttings just after the first few rains. It is susceptible to rot if the ground is inundated, but its establishment should be no problem on well-drained soil. The optimal size for a cutting is one meter long and six centimeters across. The cutting should be cut cleanly at both ends and be allowed to scab over before being planted out. (One week of drying in the shade is sufficient. Overdrying would cause a loss of viability).

If there is very little stock in the region, the Commiphora africana should be replaced by something else until enough stock is brought in. It is not often a gregarious species and great effort would be required to procure the requisite number of cuttings. Since it is spaced at about 30 cm, 100 meters of fencing would require 300 cuttings.

Balanites aegyptica and Ziziphus species : These species have potential as a live-fencing plant; however, they are rarely, if ever, traditionally used as such. The branches of the species have thorns which are favored for dead fencing. Their establishment is relatively easy as they can be directly seeded. However, these species are heavily browsed. If they are given good protection, and if they are top-pruned, they would serve well as live fences. Furthermore, the cuttings would provide the basic source for dead fences, and the wood is valued for tool handles.

The planting of the seed is quite easy. The fruit of the two species is often found in the market where it is sold as food. The planting sites are staked out and a trench is dug which forms a catchment basin.

The seeds are treated with HCH (great care is taken to ensure that none of the treated fruit is consumed) and sown at about five seeds to the meter. This takes place in June. After germination, the saplings must be released from competition of weeds, and must be protected from animals.

Prosopis juliflora: This is imported from North America and Mexico where it is known as mesquite. There are a couple of live fences of Prosopis juliflora in the Sahel and it appears to be a hardy species. Furthermore, like the Acacia albida, it belongs to the legumonosae family and is potentially a nitrogen-fixer.

C. Site Selection and Establishment of Live-Fencing

A reliable method of choosing a site is to look for the presence of an existing dead thorn fence. The farmer is then asked if he would like to establish a live fence. If the farmer indicates such a desire, he is provided with the basic stock and instructions. If the fencing is to be directly seeded, the farmer prepares the ground as described in section B. He sows in June. For the Commiphora africana, the farmer receives the cuttings in May and June, digs a hole one third the length of the cutting, and plants it. For all plantings and seedings, the farmer should mark the line with a series of stakes.

V. Personnel and Administration: The Delivery System

A. The Dual Needs of New Technology

Development projects require a strong delivery system as well as sound techniques. New techniques must be demonstrated to the farmer in his own environment if they are to be effective. New technology often requires materials such as new seed varieties, fertilizers and insecticides which must be imported. Thus, while very modern technology is generally appreciated for its potential, its noticeable absence in the Sahel is because of the capital required in both time and money to effectively implement the new methods.

The *Acacia albida* project employs very simple techniques, and uses resources which are available locally and familiar to the farmer. Whereby the time-lag between planting and pay-out may be several years in the case of some components of the project (the *Acacia albida* tree itself will not bear remarkable influence for 10 years), the extension cadre is trained and deployed quickly, and a multiplier-effect can be quickly realized.

Thus, even though this development project is based upon perennials which normally show less dramatic changes than annuals, the techniques are easily replicated, and the returns increase geometrically with very little management, after the perennial is established.

The crux of the current situation in the Sahel rests with the management of natural resources. Land management concepts must be implemented, and this implementation must be done on a wide scale. It can be pointed out that the time lag between the conception and implementation of forestry resource management in the United States was fifty years. (Management concepts were included in forestry plans before 1900, but the actual widespread implementation of management plans did not occur until the 1950s). In short, the establishment of useful species in a multi-purpose land management scheme offers a solution that is workable on a large scale, and this scheme is immediately operational.

B. Personnel Responsibility Schedule

1) Farmers: The farmer is the direct beneficiary of the program as the trees will be planted on his land. The farmer is also the chief implementer of the program as he executes all operations that take place on his land. Furthermore, he understands that he must maintain a basic standard in terms of work schedule and tree-survival rate. If he drops below this standard, he realizes that he is obliged to replace the dead trees, lose food rations or drop himself from the project. In the case that he drops out of the project, the farmer must relinquish his tools to another farmer. The individual attention paid to each farmer is expensive; however, it is necessary in order to encourage the voluntary implementation of a concept in a few short years. Finally, the successful farmer is the main means of an active and popular advancement of natural resource management.

The farmer is primarily responsible for:

a) The field lay-out;
b) The preparation of the planting site;
c) The planting of the trees;
d) The releasing or cleaning of the trees;
e) The management of his trees;
f) Maintaining a minimum survival rate by replacing dead stock.

2) Labor: This project requires a sustained labor force to ensure smooth implementation. Laborers are engaged for the following operations:

a) Nursery operation (which may include picket preparation and treatment)
b) Guarding the food and tool warehouses;
c) Transport activities;
d) Treatment activities;
e) Village wood stands (this is generally done completely as a food for work activity whereby the village is allocated an amount of food for the planting and management of the trees).

3) Field Supervisor (Surveillant): The field supervisors will, in most cases, be employees of the Chadian Forestry Service. They will be in direct and continual contact with the participating farmers in order to ensure that operations are executed properly and on a timely basis. Their job is not to force the farmer to perform, but rather to encourage and instruct. Their responsibilities include the following:

a) Demonstrate and supervise the staking out of fields, and report on completed fields;

b) Assist in the lay-out and operation of the nursery;

c) Submission of a final, collated report on the participating farmers, location of fields, number of stakes in each field, and best possible location to pre-position pots. This report will include a rough map of the area and will be submitted no later than the third week of May.

d) Direct the pre-positioning and protection of pre-positioned pots;

e) Demonstrate and supervise the correct planting of the trees. Report number of trees planted by each farmer;

f) Demonstrate and supervise the protection of the trees which includes fence construction, fire control, and releasing.

g) Spray trees with insecticide when necessary;

h) Periodic reporting on the condition of the seedlings and counting of losses;

i) Direction and supervision of the layout, planting and protection of live fencing and wind breaks;

j) Control of laborer time-sheets and of operations completed by the farmer for the distribution of food (payment).

k) Make food distributions;

l) Animation and training of farmers.

4) Field Technician (Préposé): The field technicians will be employees of the Chadian Forestry Service, and in accordance with the organization of the Forestry Service, they will be the direct superiors of the field supervisors. They are expected to perform and complement many of the responsibilities of the field supervisors, especially during the planting and protecting operations. Their specific responsibilities include the following:

a) Select candidates for the project;

b) Demonstrate and supervise the staking out of fields. Report names of participating farmers;

c) Direct and supervise the layout, construction, and operation of the nurseries;

d) Locate and direct collection of potting soil;

e) Initiate collection of seeds;

f) Time permitting, assist the field supervisors with the report required for pre-positioning of pots. The field technician, being a technician, may have more experience in rudimentary mapping;

g) Along with the field supervisor, demonstrate and supervise the planting of the trees. For this operation, all others will be postponed, and everyone in the program will devote their time to planting;

h) Reporting on trees planted;

i) Direct and supervise the protection of the trees, and survey and report on the condition and the survival rate of the planted trees;

j) Keep labor time-sheets for payments;

k) Make food distributions and keep inventory of food and tools;

l) Animation and training of farmer.

5) Technical Officer (Adjoint Technique): The Technical Officer, or Forestry Engineer, is an employee of the Chadian Forestry Service and is, by the Forestry Service definition, superior in rank to the field technician and the field supervisor. His primary responsibility will be one of training, technical control, coordination of operations, direction of operations, monitoring of operations, and reporting. He will also be responsible for the direct supervision and implementation of operations with the farmers and laborers, where the field technician and field supervisor is not able to complete the task. His operations responsibility will include:

a) Official visit to departmental heads to explain the project and to solicit support;

b) Make initial village visit, do questionnaires to survey response, and physically survey the area for its appropriateness for planting. Report results to the central office;

c) Make selection of candidates. Demonstrate and monitor the staking-out operations. Collect and collate reporting on field lay-out completion. Submit names of farmers and total number of stakes to the central office;

d) Select and negotiate the contract for the nursery site location;

e) Direct the layout and construction of the nursery;

f) Training, instruction, coordination and monitoring of nursery operations;

g) Initiate and coordinate the collection of seeds;

h) Coordination of the pre-positioning of seedlings;

i) Demonstrate, supervise and coordinate the planting of the trees. As with the field technician, the technical officer will be expected to be directly involved with the planting operation as this is such a vital and intense operation. Collation and submission to head office of reports on trees planted;

j) Demonstration, supervision, coordination and monitoring of the protection of the trees. Receive, collate and submit to head office, the field reports on the survival status of the trees;

k) Select the sites and supervise the layout and planting of village fire-wood stands (village forests). Report the locations and number of trees planted;

l) Monitor the live fencing operations, and report the locations to head office;

m) Coordinate food distribution and warehouse management;

n) Liaison with Government ministries;

o) Animation and training of the farmer.

6) The CARE-Chad Role: CARE-Chad participates directly, in cooperation with the Chadian Forestry Service, in all aspects of the project, including the supervision and implementation of field activities. Furthermore, the CARE-Chad forestry technicians have an important role in passing on their knowledge to Forestry Service Personnel. As in any international effort, CARE-Chad personnel can contribute new ideas and techniques. On the other hand, CARE is very aware of the expertise and pratical field knowledge which already exists in the country, and helps to promote and implement this resource.

As stipulated in the project agreement, CARE-Chad is responsible for all accounting of funds as well as for the purchasing and timely delivery of all materials, tools, and food.

C. The Farmer Incentive Component

For most farmers in the world, the establishment of perennials on their farmland for long-range benefits is a new concept and not easy to visualize. This is especially true of the Chadian farmer. He farms on a subsistance level, and the use of his energy is precious. As previously stated, the goal of this project is to gain widespread advancement of resource management in a few years, whereas the same process has taken over half a century in the United States. To accomplish this, the project must possess some dynamic components, some short term pay-outs, and incentives that hold the attention of the farmer during the establishmnet of the perennials.

These incentives will include:

Tools: The tools are top quality hand tools which are easier to handle and which hold a better edge than the tools currently used by the farmer. They will not only lessen his tree-planting work now, but will also facilitate his normal agricultural activities.

These tools will be given to each farmer on a loan basis at the beginning of operations. At the completion of the operation and upon meeting the required standards, the farmer is told that the tools are his to keep and use for follow-up protection activities. For those who do not complete the operations sucessfully, the tools will be collected and the farmer dropped from the program.

Food: The work involved in the planting and protecting of the trees is physically very demanding, and it falls at the peak of the farmer's normal agricultural activities. Also, at this time, his food reserves are quite low and his energy requirements are high. To offset these extra nutritional and energy requirements, food is given to each farmer who participates in the program.

It should always be emphasized that the tools and food are given by CARE as assistance to the farmer to implement the program for his own benefit.

D. Field Report Schedule

Monthly or periodically written reports will be submitted by the field technicians and supervisors. These reports will fall into two categories: Progress Reporting and Request Reporting.

a) Progress Reporting: This reporting is to assure the central office of the timely implementation of the program, to advise of problems, give advance notice for vehicle control, and provide necessary information for the records. Also a regular reporting schedule will help the field personnel follow an organized and regular work schedule. The form for this type of reporting will be a simple list of the farmers, on which columns may be marked for necessary information. (For an example of this list, refer to the Bougoumène sample copy in section VII).

The various progress reports are:

Acacia albida Plantation Field Layout and Candidate Selection: This initial report will be submitted to the control office as the fields are laid-out. This will constitute a list of the names of participating

farmers, who have terminated the field lay-out work and who have received their monthly ration.

Pre-positioning Report: By the submission of the May report, a complete list of the farmers, the number of stakes each has in place, and the position of each farm will have been sent to the central office.

As this list will be used for pre-positioning the pots and pickets, it will be accompanied by a map of the area, indicating the most convenient drop-off points. This report may be completed over several months as farmers finish lay-out work but the final and complete report must be submitted in May.

Windbreak and Village Firewood Sources Site Locations: By March, a report will be submitted indicating the locations of future wind breaks and village firewood stands. This report will serve to direct tree despatching at the proper time.

Live-Fencing Site Selection and Demarcation: By the second week of April, a report will be submitted indicating the sites chosen for live-fencing and deflection barriers.

Planting Completion Reports: By the third week of August, or as soon as planting is over, a report will be submitted indicating the total number of trees planted in all fields. This report will also indicate which fields are in fallow and which are grain fields.

Releasing Report: By the fourth week of September, a report will be submitted indicating the fields which have been properly released. This report will also advise on the need for insect control.

Fencing Report: This report will be submitted immediately after fencing, but no later than the second week of December. As well as indicating the completion of the fencing, it will also report on fire control.

Beating-Up Report: By the second week of April of the following year, a list of the mortalities will be submitted in order that trees may be delivered for replanting.

Tool Distribution Report: A report will be submitted after each tool distribution, using the "fiche des outils" (see section VII for example).

b) Request Reporting: A complete list of needs will be sent to the central office in the form of one report, on Saturday of each week. No more than one request report will be sent per week. This report will contain:

Food Request: This request will be made using the vehicle request form and will either be prepared or approved by the food controller for the area. On the reverse side, the blank side, of the form, the existing stock in the warehouse will be noted.

Vehicle Request: The use of a truck for any purpose related to the program must be made one week in advance, except in the case of an emergency. For this, the vehicle request form will be used (sample copy in section VII).

Purchase Request: All purchase requests will be made at least one week in advance and will be made using the Purchase Request form (see section VII for sample copy).

VI. ACACIA ALBIDA PROJECT - Tool and Material Requirements

Operation	Tool or Material Required	Specifications	Requirement per Unit
Site Preparation	Iron Rods (Rebar)	1m x 4cm	1 per 100 m live-fencing
	Hatchets		1 per farmer
	Cord (rope)	100 m	1 per 40 ha plantation
	Wheelbarrows		1 per 25 ha plantation
	Stakes	30cmx4cm wood	1 per tree
	Pickets	1.20cm x 4cm treated wood	1 per meter live-fencing
Nursery	Barrels (empty)	200 liter	5 per 10,000 pots
	Engine (pump)	3½ H.P.	1 per nursery
	Tubing (plastic)	50 mm	100m per nursery
	Barbed Wire		250m per nursery
	Fence Posts	Male Ronier 2m	
	Gasoline		
	Hoes		5/10,000 pots
	Files	30 cm	10/10,000 pots
	Knives		3/10,000 pots
	Machettes		3/10,000 pots
	Measuring tape	50 m	1 per nursery
	Pruning shears		2/10,000 pots
	Picks		3/10,000 pots
	Rakes		5/10,000 pots
	Shovels		5/10,000 pots
	Hatchets		3/10,000 pots
	Watering cans		5/10,000 pots
	Shade mats	Local grass 1.20m wide	500m per 10,000 pots
	Powder spray cans		2 per nursery
	HCH		40 kg per nursery
	Burlap sacks		25/10,000 trees
	Seeds	Acacia albida Neem	6 per pot

Operation	Requirement Tool or Material	Specifications	Requirement per Unit
Nursery cont.	Pots (plastic)	30cm x 20cm x 6 micron	1 per tree
	Nails		
	Trees	Neem	
Pre-positioning and Planting	Knives		1 per farmer
	Machettes		1 per farmer
	Shovels		1 per farmer
	Watering cans		2 per 1,000 pots
	Seeds	Ziziphus Balanites	
	Truck trips		1 per 1,000 pots
Protection	Rope or wire	20m market cord	1 per 3 trees
	Gloves	Heavy Duty	1 per farmer
	Hoe		1 per farmer
	Iron rods	1m x 1m or 2cm	
	Powder Hand Pump		1 per 10 hectares
	HCH	40 kg sacks	80 kg/10,000 trees
	Sprayer(Insecticide)	Back pack	1 per 50 hectares
	Endrine	55 liter drum	1 drum/10,000 trees
	Rakes		1 per farmer
	Pickets	1.20m x 4cm	4 per tree
Picket Collection	Bow saw		20/100,000 pickets
	Lopping shears		10/100,000 pickets
	Hatchets		20/100,000 pickets
	Machettes		20/100,000 pickets
	Files	30 cm	50/100,000 pickets
	Endrine	55 liter drum	66 liters/100,000
	Crankcase oil		4,000 L./100,000
	Barrels (empty)	200 liter	16/100,000 pickets

Operation	Tool and Material Requirements	Specifications	Requirement per Unit
Picket Collection	Gloves	Heavy duty	10/100,000 pickets
	Rope	Market cord 20m	500/100,000 pickets
	Wheelbarrows		10/100,000 pickets
	Truck Trips		1/1,000 pickets
Vehicles	Land Rover		2 per year
	Mobylettes		10 per year
	Bicycles		30 per year
Miscellaneous	Locks		1 per food warehouse
	Chains		1 per food warehouse

VII. Forms and Contracts

Form used in the project are the following:

1) Questionnaire (Enquête): This form is used to survey the responsiveness of an area for the program. This questionnaire serves more as a guide for discussions than an actual study.
2) Food Distribution Form (Fiche de Vivres): This form is used for the distribution of food.
3) Tool Distribution Form (Fiche de Outils): This form is filled in as tools are given to the farmer.
4) Control Sheet: This form is used to control the activities of an area up through planting and the distribution of tools.
5) List of Farmers (Liste de Cultivateurs): This is a sample copy of the general reporting form on farmers for all activities. Columns may be drawn in as required for the recording of each operation.
6) Service Contract (Contrat du Service): This form will be used for the rental of warehouses, vehicles, etc., where necessary. It will also be used for the contracting of special services such as building a well or fence, etc.
7) Purchase Request Form (Formule Pour L'Achat des Marchandises): This form will be used for all purchase requests. It will be filled in either by the field technicians or the CARE representatives a week in advance of the required purchase date, approved by the field representative and authorized by the CARE Director.
8) Vehicle Request Form (Formule pour l'Utilisation des Véhicules): This form will be used to request the use of a CARE vehicle. It must be presented to the CARE office a week in advance and be approved by the CARE field representative.
9) Food Inventory Form (Registre de l'Inventaire): This form will be used for recording the amount of food available at each warehouse and will be the responsibility of the food control man.

10) "Déplacement des Mobylettes et de Velos": This is a memorandum for the control of project mobylettes and bicycles.

11) Work Completion Report (Rapport Journalier): This is to be submitted weekly by the field supervisor to the central office, giving details of the daily activities of the field supervisor, for organisation and pay purposes.

12) Short-term Work Contract (Contrat de Travail à Durée Déterminée): This is used for contracting masons, carpenters, etc. for short-term projects or specific jobs.

13) Participation Contract for the Acacia albida project (Contrat d'Engagement au Projet Acacia albida): This contract is between the Forestry Service and the individual participating farmer and sets down the responsibilities and obligations of each party.

Form 1

ENQUETE SUR LE PROJET DE PLANTATION D'ACACIA ALBIDA

Nom _____

Année de naissance _____ âge _____

Lieu de naissance _____ tribu _____

Lieu de résidence _____

ENQUETE

1. Combien de temps avez-vous vécu ici? _____
2. Quelle est la grandeur de votre champ de mil? (en corde) _____
3. Ce champ-vous appartient-il? _____
4. Votre père est-il (était-il) cultivateur? _____
5. Quelle sorte de mil cultivez-vous? _____
6. Cultivez-vous d'autres cultures? (oui ou non) _____ Quelles sont ces autres cultures? _____
7. Est-ce que vous connaissez cet arbre (en indiquant l'albida)? _____
8. Dans votre vie, quel rôle jouent les Acacia albida ? _____
9. Sont-ils trouvés petits et protégés? (Comparez-les à d'autres espèces existantes) _____
10. Ont-ils d'avantage pour les cultures? Quel est cet avanatage? _____
11. Ont-ils d'inconvénient pour les cultures? Quel est cet inconvénient? _____
12. En leur fournissant les matériels, acceptent-ils d'élever les plantes en pépinière, de les planter dans les champs et de les protéger jusqu'à ce qu'ils deviennent grands? _____

.../...

13. Arrive-t-il quelque fois qu'un grand vent abatte à terre les pieds de mil?

_____

_____

_____

14. Si oui, accepteriez-vous de planter quelques arbres en lignes pour empêcher les dégâts du vent? _____

_____

_____

15. Est-ce qu'il y a des dégâts lors de passage des animaux domestiques dans les champs? _____

_____

_____

16. Si oui, avez-vous trouvé des moyens pour empêcher les dégâts des animaux?

_____

_____

_____

17. Quels sont ces moyens? _____

_____

_____

Form 2

PROGRAM COMMUN

GOUVERNEMENT DU TCHAD ET CARE-CHAD

Nom de la personne: _____

Vivres disponibles (pour participation minimum de 25 heures):

_____

_____

_____

Dates	Heures Complétées	Dates	Heures Complétées

Heures Totales _____

Je certifie que cette personne a complété le minimum de 25 heures.

_____

Signature et Cachet

Je certifie que j'ai reçu les vivres cités ci-dessus.

_____

Signature

Form 3

PROJET ACACIA ALBIDA

PROGRAMME COMMUN - EAUX ET FORETS ET CARE-CHAD

Nom de la personne _____ Village _____

Date	Outils reçus	Signature d'Agriculteur	Date	Outils reçus	Signature d'Agriculteur
1.			11.		
2.			12.		
3.			13.		
4.			14.		
5.			15.		
6.			16.		
7.			17.		
8.			18.		
9.			19.		
10.			20.		

_____

Signature d'un Responsable de la CARE-Chad

_____

Signature des Eaux et Forêts

Form 4

N°

																									Nom
																									Houe
																									Marteau
																									Hache
																									Matchet
																									Piquets Livrées
																									Piquets Mise en place
																									Remunérations
																									Pots Livrées
																									Pots Mise en Place
																									Poteaux Livrées
																									Poteaux Mise en place
																									Pelle
																									Couteau
																									Remunérations
																									Epines Mise en place
																									Remunérations
																									Gants
																									Rateaux

Form 5

Projet Acacia albida

Liste des Cultivateurs

1976

Village de: Bougoumène

Noms des
Agriculteurs

01 Mahamat Abdallah
02 Tchanga Gana
03 Kambete Dassou
04 Dassou Yakaina
05 Saumaye Sily
06 Djana Dahaina
07 Mithna Dahai
08 Djona Dagdam
09 Gaula Tchauina
10 Saulaukna Sounaye
11 Hakassou Toukou
12 Youmique Tchilaman
13 Haunanga Ousna
14 Haissiny Habnassou
15 Nguiside Tarrena
16 Damma Doumona
17 Baissama Tokou
18 Toukou Yaoma
19 Bellema Abdellah
20 Ngassina Mounona
21 Tchaitoumo Libitana
22 Nargue Dihana
23 Soubourrou Danma
24 Hindjema Togou
25 Foulah Libitna
26 Seydou Kane
27 Roumissou Tchoukoussoa
28 Yabama Danma
29 [illegible]
30 Ngarlo Seke

.../...

Projet Acacia albida

Liste des Cultivateurs

1976

Village de: Bougoumène

Noms des Agriculteurs

31 Modoussere Laoussa

32 Bourahou Siga

33 Bataum Dassou

34 Tcouna Haboum

35 Halyam Mangan

36 Blama Abdoullah

37 Koutou Koa

38 Tchiropla Mambassou

39 Hinekissa

40

41 Hinsou Boussaina

42 Dabaina Boussaina

43 Patcha Gadjal

44 Hadsou Klanna

45 Mobé Bassa

46 Sanodji Alain

47 Ngarade Augustin

48 Hassan Bagoulou

49 Halao Marty

50 Sinkai

51 Sina Hakna

52 Modissini Marty

53 Magamere Abele

54 Daumba Djantar

55 Houyou Aiele

56 Nagassou Bousseina

57 Safalamo

58 Blama Bruno

59 Hissou Bousseina

60 Sougna Sounai

Form 6

Numero du contrat _____
(Contract Number)

Contrat du Service

(Contract for Services)

CARE-Chad
B.P. 106
N'Djamena
Tchad

Entre
(Between) _____

_____

et
(and) _____

Pour les Services suivants:
(For the following services)

Description des services:
(Description of Services) _____

_____

_____

Prix des Services:
(Price of Service) _____

Conditions de Paiement:
(Terms of Payment) _____

Compris dans le Prix sont les Services suivants:
(Included in the price are the following services) _____

_____

_____

Non Compris sont les Services suivants:
(Not included are the following services) _____

_____

Conditions Spéciales:
(Special conditions) _____

Le Service sera fini au plus tard le _____. Pour chaque jour en retard, CARE-Chad recevra une réduction comme amende de _____ francs CFA par jour.
(At the latest the service will be completed by _____. For each day of delay CARE-Chad will receive a reduction of _____ CFA per day).

Pour CARE-Chad

_____

_____

Date

Pour le Contrat

_____

_____

Date

FORMULE POUR L'ACHAT DES MARCHANDISES

(A remplir au minimum une semaine d'avance)

Date: _____

Soliciteur: _____

A. Acheter les suivantes:

	Quantité	Article	Prix estimatif	Observations Dimensions, vendeurs, etc.
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

B. Ces marchandises seront chargées à PCN: _____ Code: _____

C. Ces marchandises seront envoyées à: _____

D. L'argent nécessaire pour payer les manoeuvres: _____

E. Les marchandises doivent être sur place avant le: _____
(date)

Autorisation du Directeur

_____
Signature

A remplir après les marchandises sont achetées et envoyées.

Envoyé: _____
Liste _____
par _____
Numéro _____

Date: _____

Numéro de bordereau: _____

Form 8

FORMULE POUR L'UTILISATION DES VEHICULES

(A remplir au minimum une semaine d'avance)

1. On a besoin de:_____ Camions.
2. Pour aller à:_____
3. Le camion sera charger avec:_
   a._____
   b._____
   c._____
   d._____
   e._____
   f._____
   g._____
   h._____
   i._____
   j._____
4. Le camion doit voyager le:_____
   Jusqu'au:_____ (date)
5. L'argent nécessaire pour payer les manoeuvres:_____ (date)
6. Qui sera responsable pour les marchandises qu'on va décharger:_____
   _____
7. Est-ce-qu'il faut un camion spécial?_____

_____
La personne qui fait la Commande

_____
Date

Form 9

PROJET - ACACIA ALBIDA

Registre de l'Inventaire pour le Mois de:_____

Nom du Village:_____

Nature de Vivres :_____

DATE	MARCHANDISES EN MAGASIN	ADDITIONS	DEDUCTIONS	SIGNATURE

Form 10

CIRCULAIRE A L'INTENTION DES AGENTS DES EAUX-FORETS ET DES SURVEILLANTS BENEFICIANTS COMME MOYENS DE DEPLACEMENT DES MOBYLETTES ET DES VELOS.

-==oOo==-

Il m'est arrivé de remarquer à plusieurs reprises que les Agents des Eaux et Forêts et les Surveillants travaillant dans le Projet Acacia Albida utilisent les mobylettes et les vélos dans l'état d'ivrogne; ceci est regrétable.

1° A partir de la date de signature de cette circulaire, après le travail c'est-à-dire à partir de 12 heures et zéro et de 18 heures pour ceux qui travaillent le soir, tous les vélos seront enfermés dans le magasin du projet. Ils seront fermés à clé et ne peuvent sortir du magasin que le lendemain à partir de 6 heures 30. Les mobylettes peuvent être gardées par les agents des Eaux et Forêts bénéficiants.

2° Celui qui fera accident avec les véhicules du projet dans l'état débraillé prendra à sa charge la réparation de l'engin.

3° Il est interdit à tous les Agents des Eaux et Forêts et les Surveillants d'utiliser les Mobylettes et les Vélos pour leurs courses personnelles les jours de repos et en dehors des heures de travail.

4° J'attire l'attention de tous les Agents et les Surveillants pour le bon respect de cette circulaire.

FAIT A N'DJAMENA, LE 15 - 12 - 76

Monsieur SYAN HOMOLOGUE TCHADIEN
auprès de la CARE - THCAD

RAPPORT JOURNALIER

DATES	NOMS DES OUVRIERS	TRAVAUX EFFECTUES	OBSERVATIONS
1/11/76	4 manoeuvres	Potenux mise en place traitement	2 champs 4 champs
2/11/76	4 manoeuvres	Potenux mise en place traitement	2 champs 4 champs
3/11/76	4 manoeuvres	Potenux mise en place traitement	1 champs 3 champs
4/11/76	4 manoeuvres	Potenux mise en place traitement	2 champs 3 champs
5/11/76	4 manoeuvres	Potenux mise en place traitement	2 champs 4 champs
6/11/76	3 manoeuvres	Potenux mise en place traitement	2 champs 4 champs
7/11/76	4 manoeuvres	Potenux mise en place traitement	2 champs 4 champs
8/11/76	4 manoeuvres	Potenux mise en place traitement	2 champs. 4 champs
9/11/76	4 manoeuvres	Potenux mise en place traitement	2 champs 4 champs
10/11/76	4 manoeuvres	Potenux mise en place traitement	2 champs 4 champs
11/11/76	4 manoeuvres	Potenux mise en place traitement	2 champs 4 champs

Form 12

CONTRAT DE TRAVAIL A DUREE DETERMINEE

1) La CARE-Chad embauche Monsieur Mahamat Koursa en qualité de charpentier pour aller travailler deux semaines en brousse, avec un salaire brut de 1.500 francs CFA plus une boîte de biscuits par jour, durant les deux semaines, avec son apprenti.

2) La CARE-Chad sera responsable de leur salaire brut et des matériels de construction.

3) CARE-Chad ne s'occupera pas de congé et se déchargera de toute responsabilité pour les maladies et les accidents de travail qui peuvent arriver.

4) Le charpentier doit réparer les magasins dans les villages divers.

5) Monsieur Kara, le magasinier du projet "Acacia albida" sera son chef immédiat.

6) Le charpentier sera responsable pour:

   A. Tous les outils de travail;
   B. La liste des matériaux de construction;
   C. Le charpentier sera responsable pour son apprenti;
   D. Le charpentier et son apprenti travailleront matin et soir tous les jours payés.

CARE-Chad

Le Charpentier

Visé par le Bureau de Main-d'Oeuvre

FAIT A N'DJAMENA, LE 29/11/76

Form 13

REPUBLIQUE DU TCHAD

Unité-Travail-Progrès

CONSEIL SUPERIEUR MILITAIRE

MINISTERE du TOURISME
de l'ARTISANAT et des RESSOURCES
NATURELLES

DIRECTION GENERALE

DIRECTION des FORETS,
de la CHASSE et de l'ENVIRONNEMENT

CARE - CHAD

SERVICE DES FORETS

CONTRAT D'ENGAGEMENT AU PROJET ACACIA ALBIDA

Un projet commun pour réaliser des plantations en Acacia albida est convenu entre le Gouvernement du Tchad et CARE-Chad pour une durée de 4 ans.

1. La participation Tchadienne consiste à mettre à la disposition de CARE-Chad du personnel forestier national pour la vulgarisation et l'encadrement de l'opération dans les zones rurales retenues.
2. Sensibiliser et motiver les populations paysannes à l'opération sous forme d'investissement humain dans l'intérêt bien compris de créer un patrimoine végétal favorable au développement de l'Agriculture pour un meilleur devenir du paysan Tchadien.
3. Les paysans cultivateurs persuadés de l'importance économique de l'opération, participeront volontairement au projet en exécutant des travaux que nécessite la réalisation des plantations autour de leurs villages et dans leurs champs sous l'encadrement technique des forestiers nationaux.
4. Ils doivent planter, entretenir et protéger les arbres que leur fournit le projet, comme leur propriété et veiller à leur survie.
5. CARE-Chad apporte une aide en vivres et outils pour encourager les meilleurs cultivateurs qui font preuve de bonne volonté et de compréhension, sans toutefois être obligé de les faire pour tous car, le rôle de CARE-Chad n'est pas de récompenser tous les cultivateurs mais de les aider pour leur bien être.
6. Tous les participants au projet à quelque titre ou qualité (surveillants et manoeuvres) ne sont pas des employés de CARE-Chad pour prétendre à un salaire. Ils doivent comprendre que CARE-Chad ne reconnaît ni leurs droits de travail, ni leurs indemnités, ni leur congés, ni leurs responsabilités des accidents de travail.

L'intervention de CARE-Chad doit être bien comprise comme une aide aux démunis qui font preuve de bonne volonté pour contribuer au développement agricole par la plantation des Acacias albida.

7. Les outils donnés aux cultivateurs peuvent être repris par CARE-Chad s'ils ne les utilisent pas dans le cadre du projet ou si la reprise des arbres plantés tombent en dessous de 60% après l'année de plantation.
8. Les Forestiers Tchadiens et les responsables du projet CARE-Chad doivent collaborer étroitement dans l'assistance technique des cultivateurs sur le terrain pour la réussite du projet, et avoir un contrat permanent avec les autorités administratives du ressort.
9. La participation effective du Gouvernement Tchadien (forestier, population et autorités) et CARE-Chad constitue le facteur essentiel pour la réussite du projet Acacia albida.

Je soussigné .....qualité..... certifie avoir prié connaissance du contrat d'engagement au projet Acacia albida.

En adhérant volontairement à ce projet, je m'engage à respecter tous les termes de ce contrat.

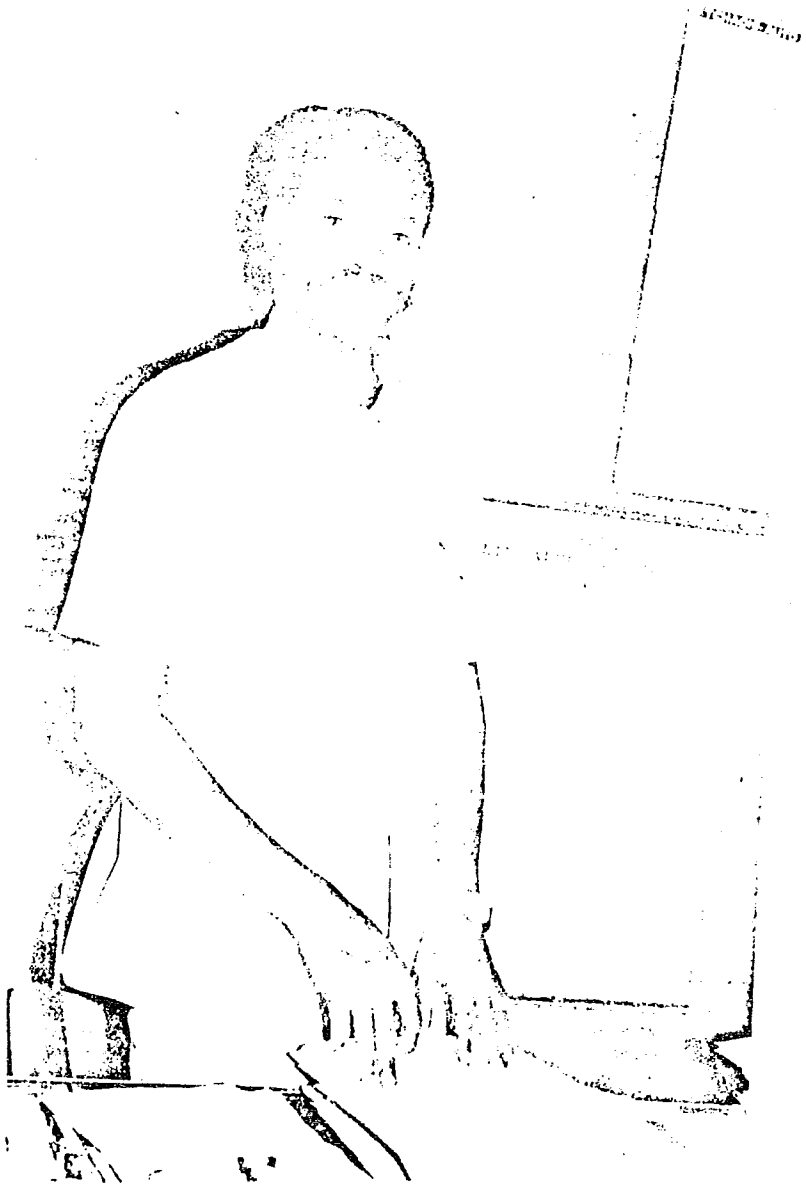
LIEU ET DATE: .....

SIGNATURE DU VOLONTAIRE

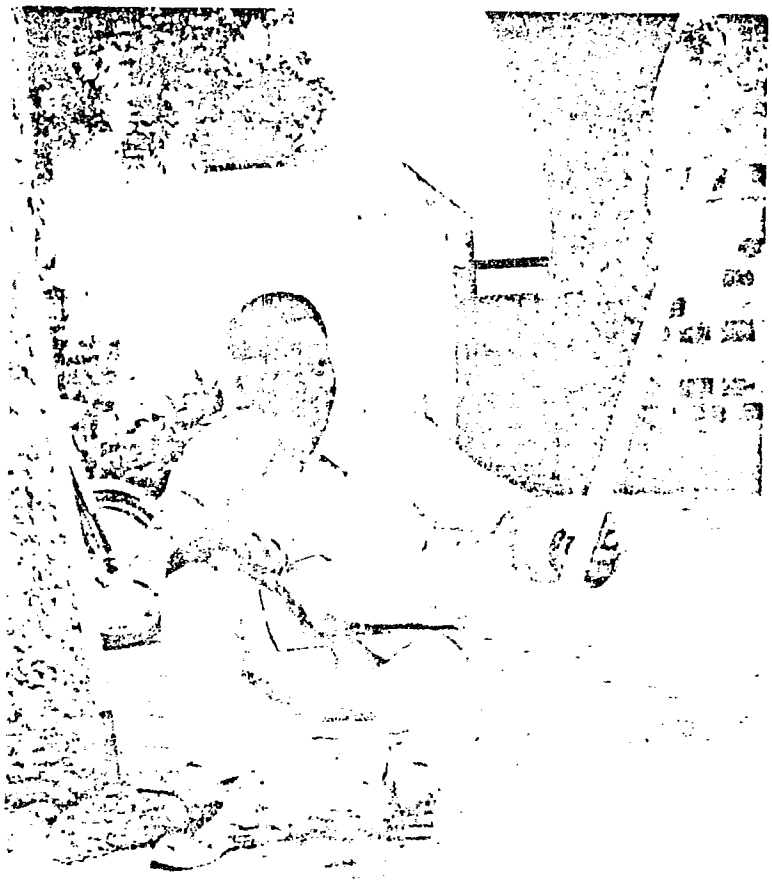
VIII. PHOTOGRAPHS

	Captions	Page No.
1.	Mr. Baba Diguera, Director of the Chadian Forestry Department	77
2.	Mr. Djimkimbayel, Director of the Chari-Baguirmi Forestry Division	78
3.	Fallow Fields - Eroded field	79
4.	Fallow Fields - Over-Cropped field	79
5.	Taungya Method	80
6.	Reverse Deciduous Cycle	81
7.	Soil Restoration	82
8.	The Village Nursery	83
9.	Nursery Operations	84
10.	Nursery Development at Mogroum	85
11.	Nursery Facilities Improvements	86
12.	*Acacia albida* Seed Pod	87
13.	*Acacia albida* Tree - Fodder and Shade for Animals	88
14.	Seed Collection	89
15.	Seeding of Pots at the Mogroum Nursery	90
16.	Crust Control	91
17.	Picket Treatment	92
18.	Village Meeting	93
19.	Field Lay-Out	94
20.	Field Lay-Out and Farmer Training	95
21.	Pre-Positioning	96
22.	Transport to the Fields	97
23.	Planting	98
24.	Emergency Planting	99
25.	Fire Control	100
26.	Fencing - 1	101
27.	Fencing - 2	102
28.	A Newly Planted Seedling	103
29.	Tap Root of the *Acacia albida* Tree	104
30.	Established Plantation - One Year	105
31.	Establsihed Plantation - Two Years	106
32.	Wood Requirements in the Sahel - Fuel	107
33.	Construction Wood	108
34.	Field and Home Utensils	109
35.	Market Shade Tree Plantings	110
36.	Multi-Use of an Established Tree Stand - 1	111
37.	Multi-Use of an Established Tree Stand - 2	112
38.	Field Protection	113
39.	Fenced Land (Demonstration of a Sustained Yield of Natural Resources from Managed Land)	114
40.	Mechanical and Living Barriers as Soil Conservation Measures	115
41.	Soil Retention	116
42.	Live Fencing - *Commiphora africana*	117
43.	Live Fencing - *Parkensonia*	118

1. Mr. Baba Diguera, Director of the Chadian Forestry Department, who has enthusiastically supported the Acacia albida project from its inception.



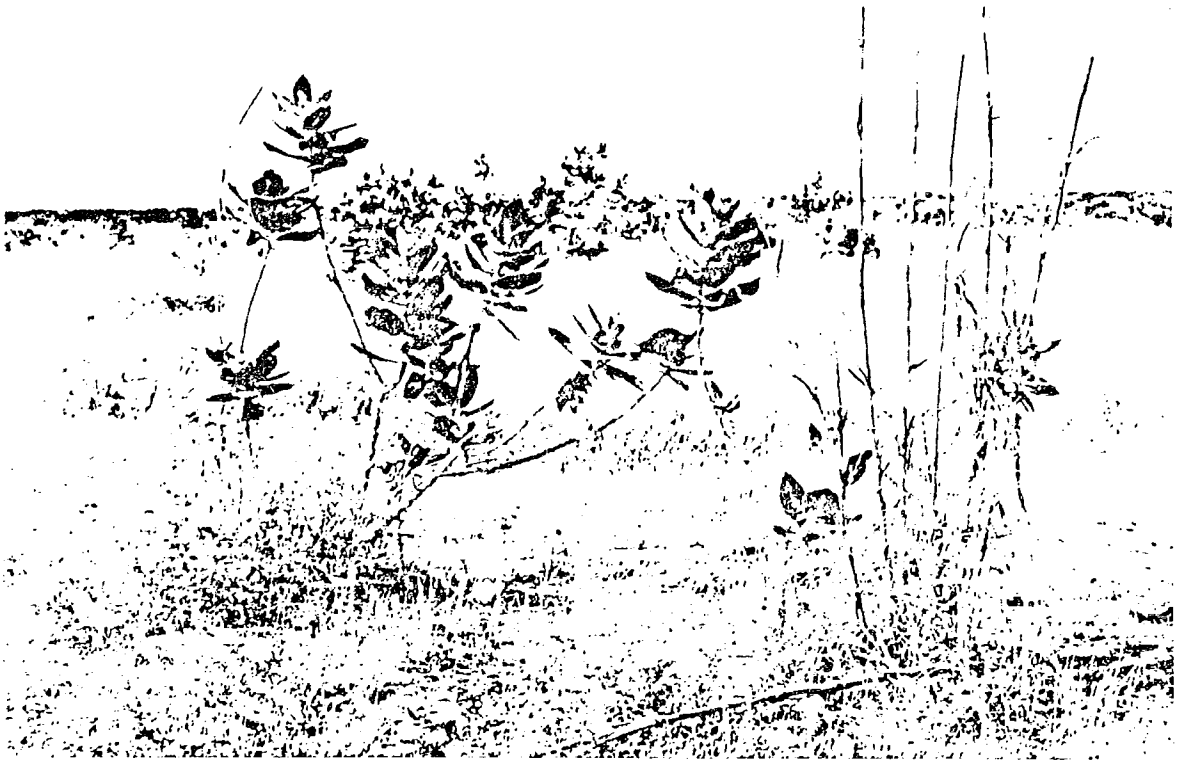
2. Mr. Djimkimbayel, Personnel Director of the Chari-Baguirmi Division of Forestry, inspecting tools to be used in the project. Those farmers who maintain a minimum rate of survival after one year, will be allowed to keep some of the hand tools.



Fallow Fields (The needs for land-use management)

3. Eroded field: With no vegetative cover to hold the rainfall, water becomes a destructive force rather than a beneficial resource.

4. Over-cropped fields: With more pressure put upon a fixed amount of land, land is cropped with annuals beyond its ability to regenerate itself within a reasonable time, and it is thus lost to the productive cycle. One indicato. of impoverished soil is the presence of Calotropis procera. This plant is becoming more common across the Sahel.



5. Taungya Method

In many parts of the world, perennials are planted with annuals for the mutual benefit of both. In Asia, this is known as the Taungya method. This project proposes to implement the same kind of multi-use plan. Not only would the soil be able to sustain its fertility for longer periods, but trees planted as wind breaks would be managed in such a way that fuel and construction wood would be harvested without damaging the basic integrity of the wood stand. The farmer would then be in a position to harvest from his land 12 months a year, while at the same time increasing the productivity of the soil. This photograph illustrates the Taungya method being applied in this program. The tree is the Acacia albida.

6. Reverse Deciduous Cycle

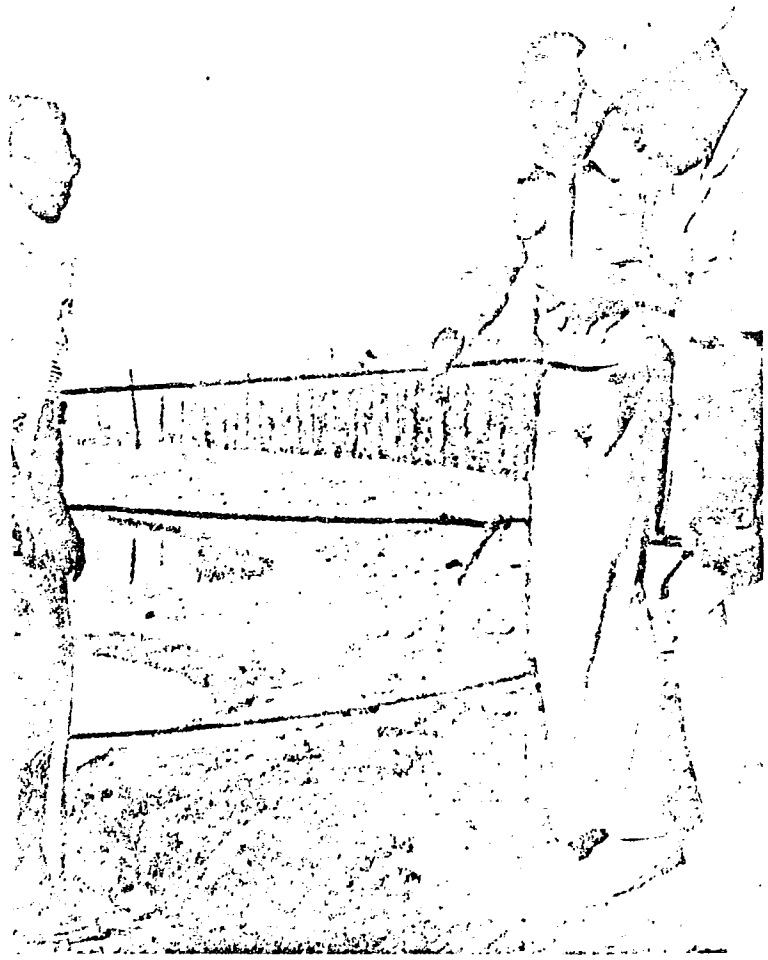
With the onset of the rains, the Acacia albida tree begins to defoliate. This phenomenon is contrary to most other Sahelian trees, and it allows tall crops such as the staples, millet and sorghum, to be cropped under the crown of the tree. The grains which grow under the canopy are afforded extra protection and recycled minerals. They reflect this extra margin of moisture and nutrition by being taller, denser, greener and generally more productive. Furthermore, grain fields having the Acacia albida do not need to be fallowed as often as bare fields. Since small margins in the Sahel mean the difference between a failure or an abundance, farmers having Acacia albida field trees have consistently better crops and fewer years of fallow.

7. Soil Restoration

This photograph illustrates the better vegetative growth directly under this *Acacia albida* tree.

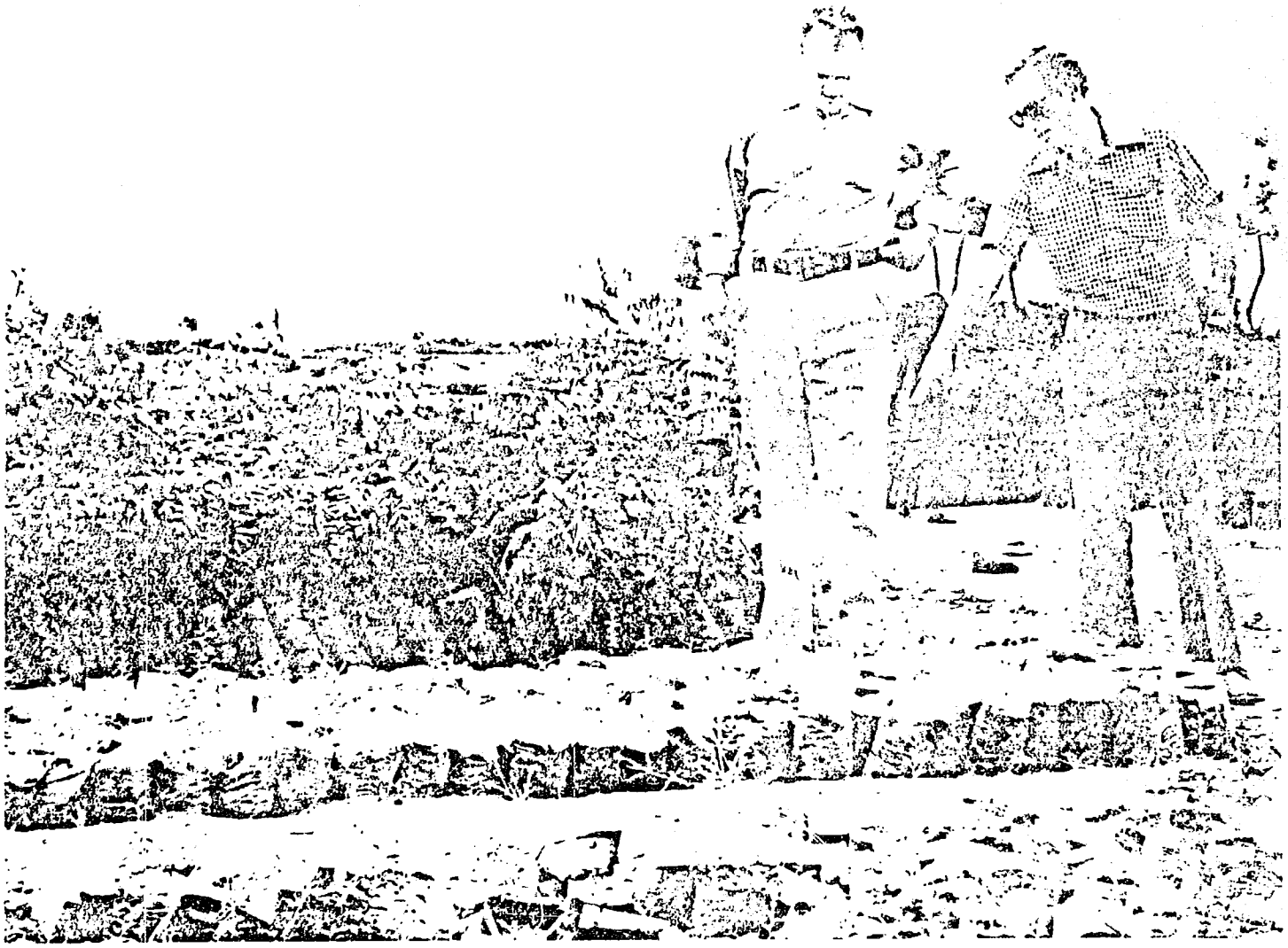
8. The Village Nursery

The most constant focal point and a center of education for farmers wishing to some day raise their own stock is the village nursery. Mr. Brahim Issa, the project supervisor at Tourba, is explaining to Mr. Syan Yassegwe, the Forestry Department Project Manager, and Mr. Senoussi, the Massakory supervisor, the plans for the nursery at Tourba. Brahim diverted water from an artesian overflow to provide water for the nursery. This water is normally wasted.



9. Nursery Operations

Lamar Prosser, Program Officer for USAID, and Mr. Val Mahan, Assistant Program Officer, inspecting the Mai-Lao nursery.

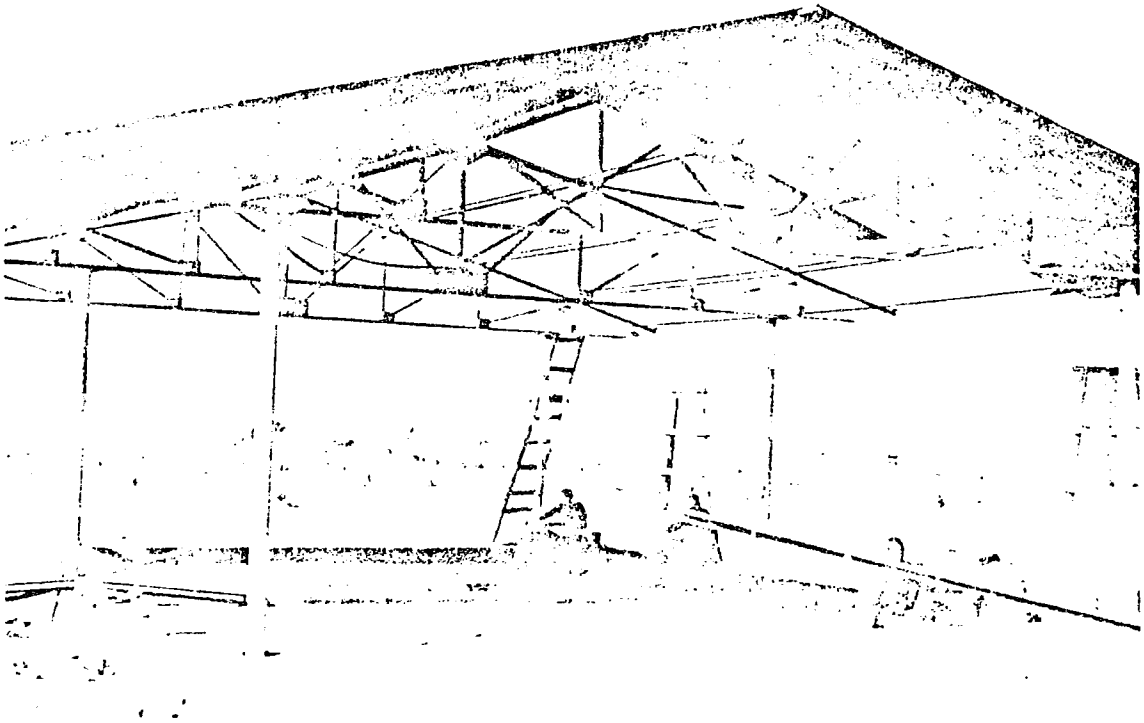


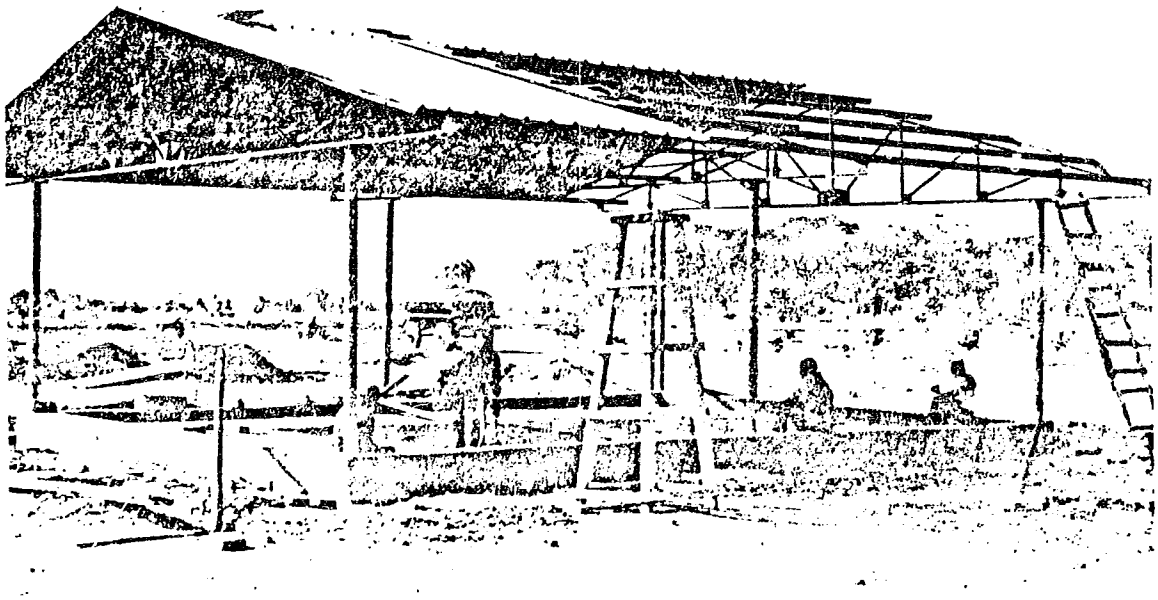
10. Nursery Development at Mogroum

Participating farmers assist in the construction of the Mogroum nursery, under the supervision of a Chadian Forestry Service agent.

11. Nursery Facilities Improvements

A seed-hulling and processing shed has been built at Milézi as part of the project.



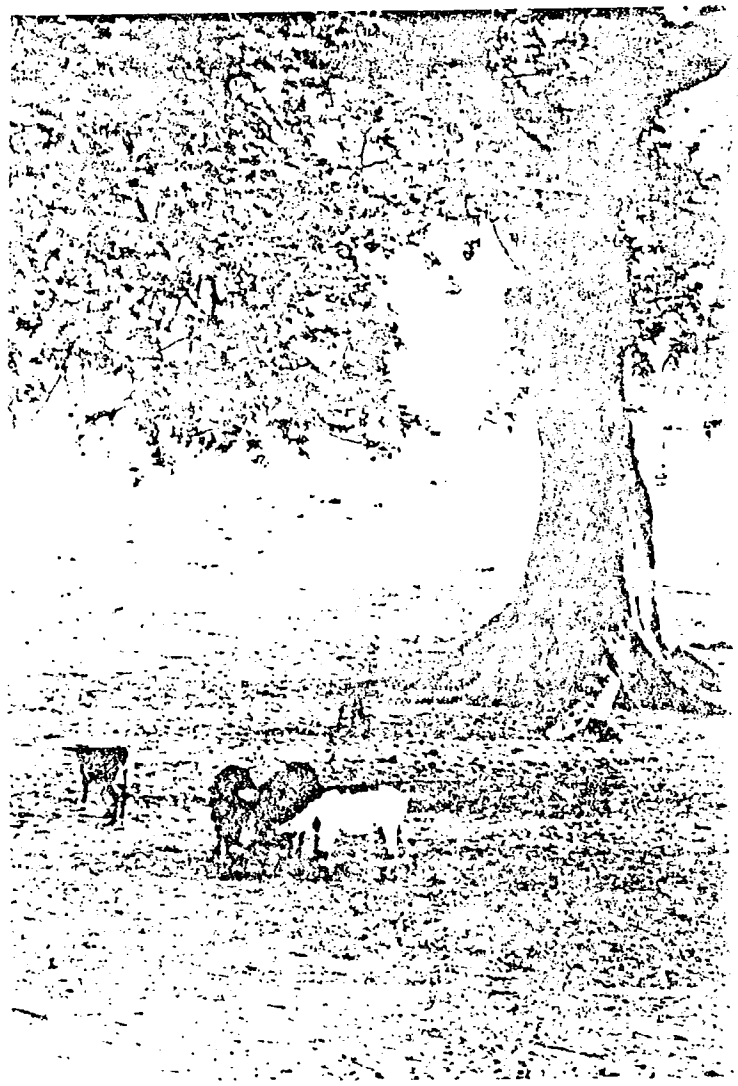


12. <u>Acacia albida Seed Pod</u>

This is a mature seed pod, ready to be collected. Farmers are encouraged to collect the mature seeds from trees that have straight boles and umbrella crowns.

13. Acacia albida Tree - Fodder and Shade for Animals

The mature seed pods of the Acacia albida tree are a favorite fodder for goats and cows. They are very rich in protein. Both the shade and this source of food attracts the animals to the Acacia albida tree, thus providing a concentration of manure in the environs of the tree.



14. Seed Collection

Acacia albida seed pods are collected directly from the tree when mature (when they are orange color in about January and February). The seeds are then separated from the pods by pounding them in a mortar. The Forestry agent in charge of the Koundoul nursery, Mr. David Baigoneia, is supervising the operation.

15. Seeding of Pots at Mogroum Nursery

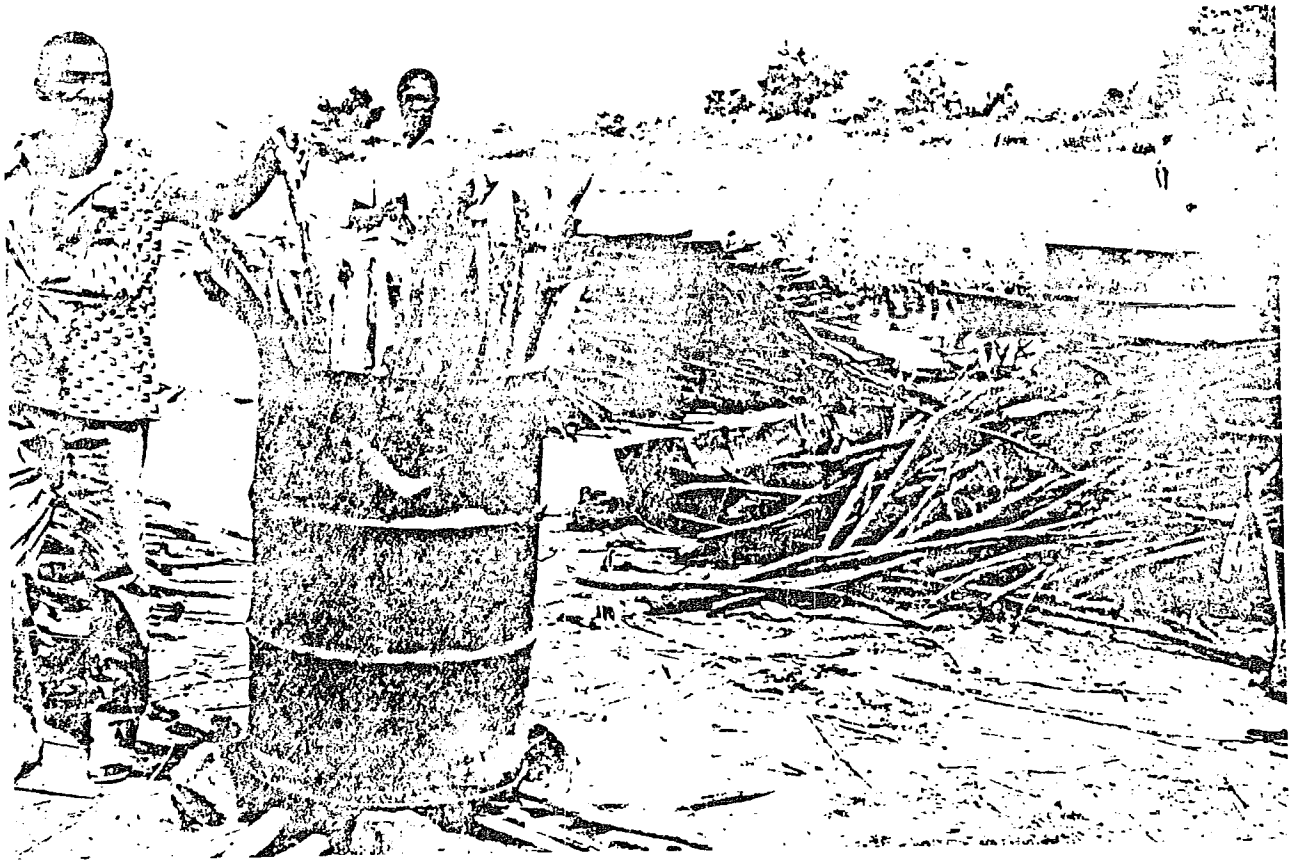
Messrs. Brahim Issa, Dingamtor Jean-Claude, and Modjimangar Abraham, project supervisors, participating in the initial seeding of *Acacia albida* seed beds in Mogroum (February 1977).

16. Crust Control

Mulching is applied to the surface of the pots, while in the nursery, in order to control the phenomenon of crusting.

17. Picket Treatment

Pickets as well as plants are badly attacked by termites if untreated. To fight the termites, as well as decay, pickets are treated in a 2% endrine solution. The remainder of the liquid is crankcase oil. An endrine-water solution should be avoided as this fights termites, but does not prevent decay. The bark should be removed from the picket before it is plunged, for twenty minutes, into the boiling solution. This is a dangerous operation and all precautions must be taken.



18. Village Meeting

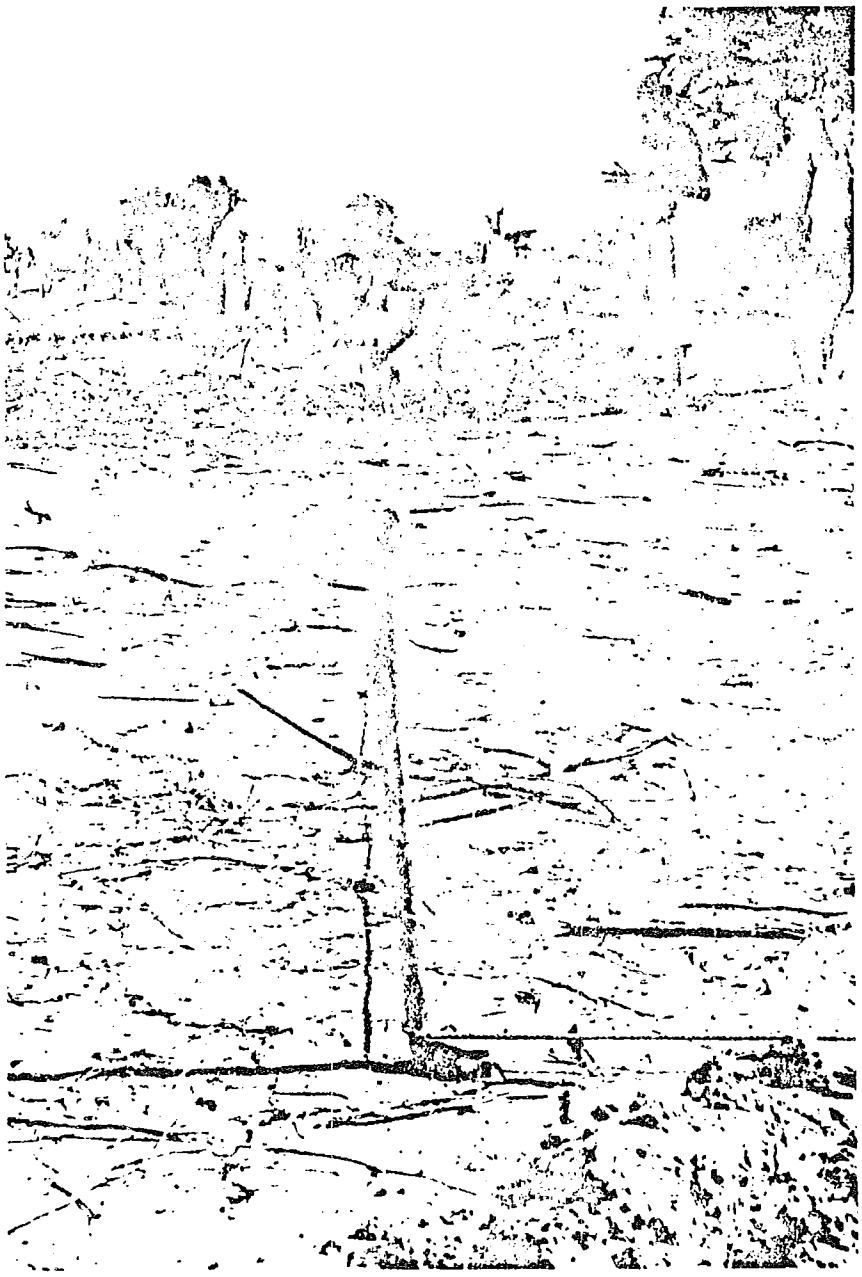
The fulcrum of success is the farmer. If he enters into the project with good faith and determination to do his part, the project will be a success, in at least that he become more aware of what he can do to improve his natural environment, upon which he is greatly dependent. In order for the farmer to fully understand his role, a bona-fide dialogue must be established. The first step in this process is the village meeting, where representatives of the project, the administration, and local authorities meet with the villagers and their notables.

The farmers is asked to give his opinion on the Acacia albida tree in particular, and on other natural resources in general. The responses to many of the questions are quite informative, and this certainly passes some of the initiative to the farmer. The objectives and operations of the project are then explained. Finally, a list is made of those farmers who desire to be participants.

In this photograph, Sultan Moumine of Mandelia is meeting with the villagers of Loumia in the initial meeting. The Sultan is a strong advocate of the idea of reforestation and plays a vital role in the project.

19. Field Lay-Out

Spacing of the fields for the planting is done by placing stakes, at ten meter intervals, in a diamond formation.



20. Field Lay-Out and Farmer Training

Farmers are instructed to find the right-angle for the staking out of their fields for the planting of the *Acacia albida* tree. Chadian Forestry Service agent, Mr. Dingmator Jean-Claude, is leading the demonstration.

21. Pre-Positioning

Mr. Mike McGahuey, CARE Forester, and Mr. Val Mahan, Assistant Program Officer for USAID, inspecting a field-holding nursery.

22. <u>Transport to the Fields</u>

The seedlings are transported to the fields, for planting, by the participating farmer and his family.

23. <u>Planting</u>

A "cookie" of about one inch thickness is cut off the bottom of the pot before planting the seedling, in order to prune the tap root and thus stimulate growth. Planting is done in the month of July.

24. <u>Emergency Planting</u>

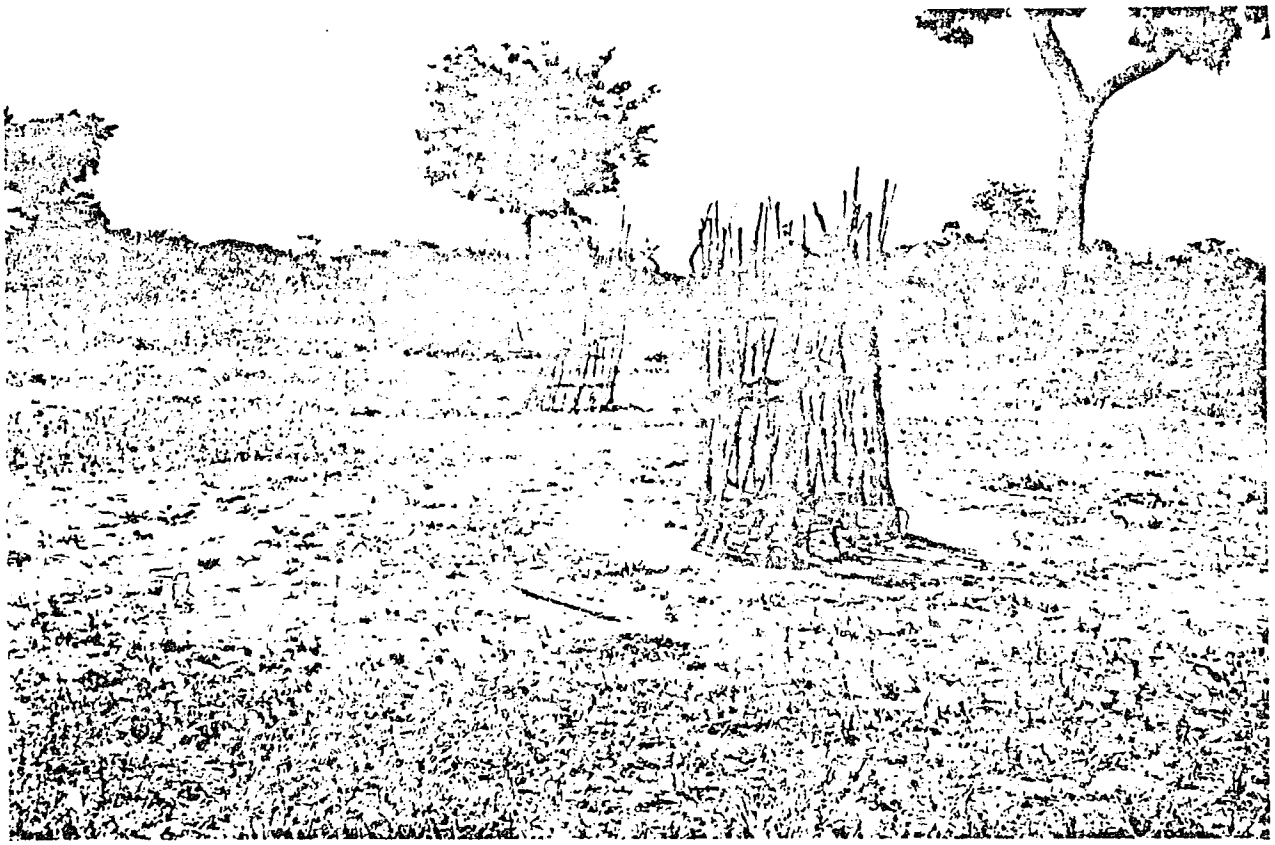
Mr. Syan Yassegwe, Chadian Forestry Service Engineer, doing emergency planting techniques, late in the planting year. Note high millet growth.

25. Fire Control

Circles of two meter radius are cleared around each sapling for protection against the constant threat of fires during the dry season.

26. Fencing - 1

Individual fences are constructed around each tree and are made from a variety of local materials. In this case, the fence was pre-fabricated at the farmer's house, using sticks tied together with bark.



27. Fencing - 2

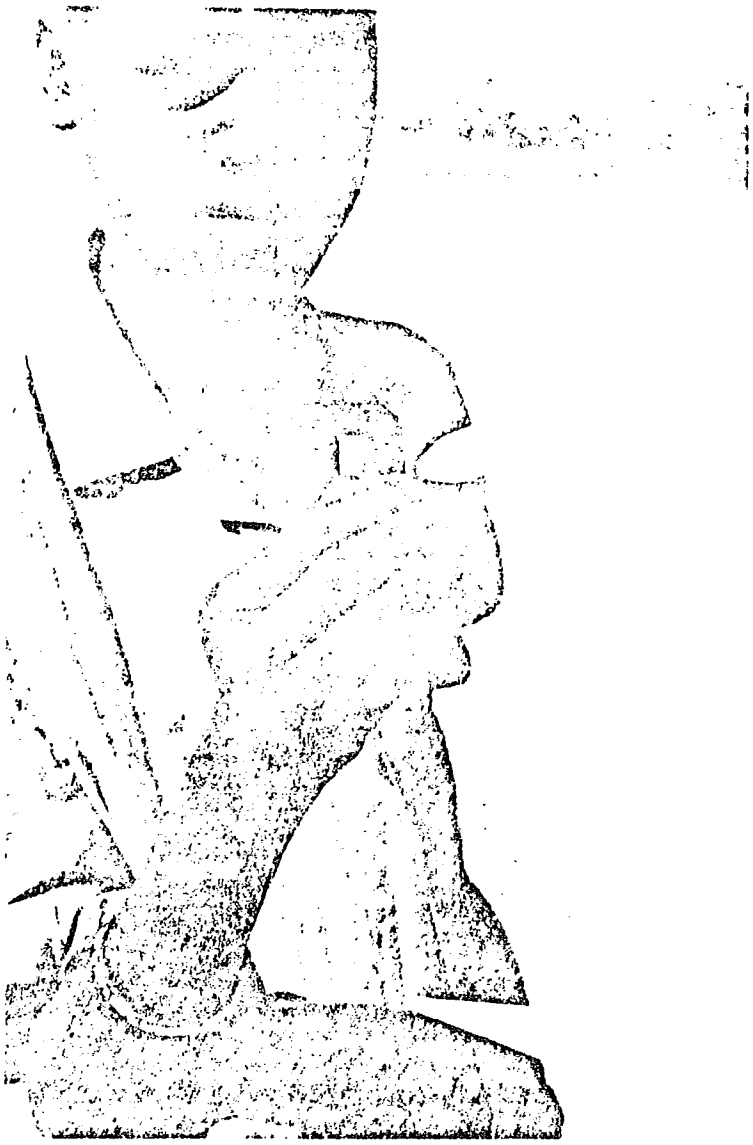
This is an example of millet-stalk fencing which has protected the trees in this field for eight months. The fencing will be repaired or replaced each year until the trees are able to fend for themselves. The fencing material was easy to find, as this was a millet field the year of planting.

28. A Newly Planted Seedling

The seedling should be in the nursery for between 10 and 12 weeks. If it is allowed to develop past this, the tap root may penetrate the bottom of the pot; a shorter period allows less margin of survival. However, if healthy and well-planted, the young *Acacia albida* will hold its own against drought, fire and animals.

29. Tap Root of the Acacia albida

Under natural conditions, the tap root development of the Acacia albida is extraordinary. This fast growing tap root system provides the tree with a healthy survival mechanism.



30. Established Plantation - One Year

Mr. Mamadou François, Chadian Forestry Service agent, inspects a champion *Acacia albida* tree, planted only six months earlier in this project. A total of 550 hectares was planted during the first year of the project (1976).

31. Estalantation - Two Years

At othe Acacia albida is lly a small, bushy plant whicn hidden by crops or r grasses. However, if all is are taken at plantme, if the soil is good and well distributed, anobaoly most importantly, if i.sed early from compebgetation, and protected fromnd fire, the seedlingdevelop into something likeyear old sapling at M. This is the largest speced one year later, fr 1975 pilot project, and ispected by CARE-Chadry Director, Peter Reit:D Program Officer, Mar Prosser.

32. Wood Requirements in the Sahel - Fuel

Virtually all of the fuel used for cooking rural food is wood or a wood product. Although the fuel industry is a major component of the rural economy, with increased pressure on the land, wood for fuel is becoming scarce. The project includes a fuel and construction wood plantation component.

33. Construction Wood

Construction wood is very similar to fuel as regards need and the situation of its source. Long poles cost more than a skilled man's daily wages; they are also becoming scarcer and scarcer, with very little management for future supplies. There are, however, State plantations at Koundoul and Milézi, and at Bongor, which have impressive reserves and which are presently under a plan for selective cutting.

54. Field and Home Utensils

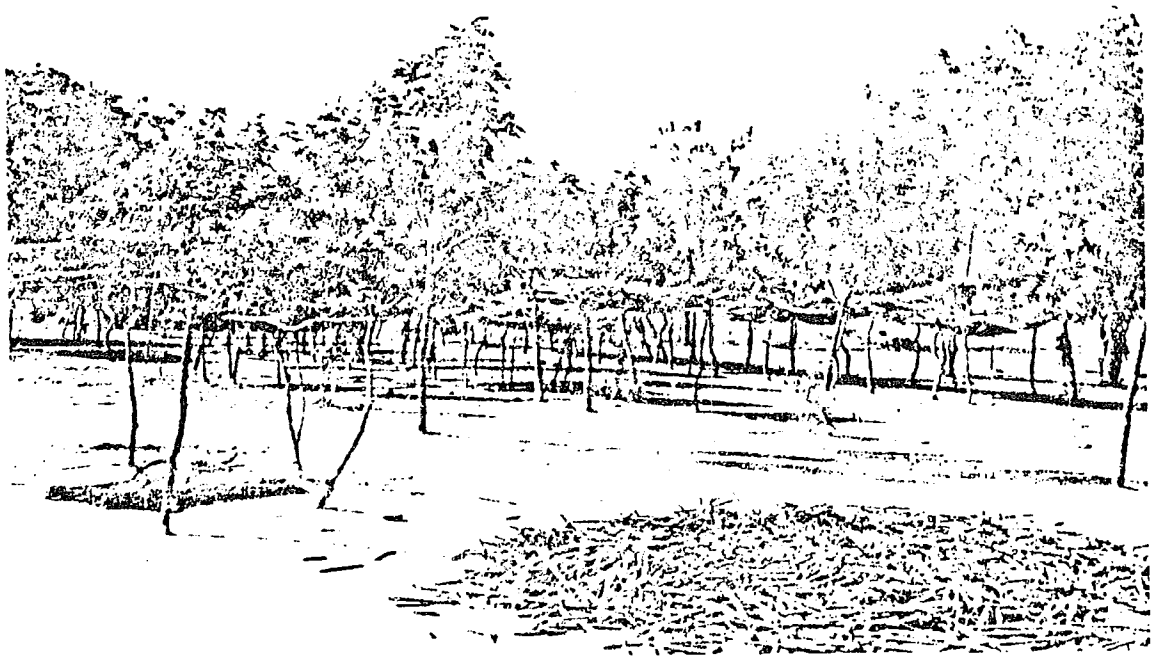
Such indigenous species as Balanites aegyptica, Prosopis africana, Khaya senegalensis, and Acacia scorpioides, provide the basic material for home utensils and handles for field tools. The photograph shows a woman using the mortar and pestle to prepare millet flour.

35. Market Shade Tree Plantings

Due to the very warm climate most of the year, the inhabitants of the Sahel must dissipate most of their body heat through perspiration. Whereas the conduction away from the body of heat by the atmosphere, as in a temperate climate, requires no body energy, body heat dissipation by perspiration requires energy. Therefore, the same amount of work in a tropical climate requires more energy than in a temperate climate.

For those villages requesting shade trees, seedlings, technical support, and some materials and food will be provided to the villagers to plant, protect and manage a shade stand. It should be pointed out that prunings can be used for fuel and construction wood.

To date this has been one of the most successful special components in some villages. The market place of Mai-Lao (see photo) has trees which are over three meters tall after one year.

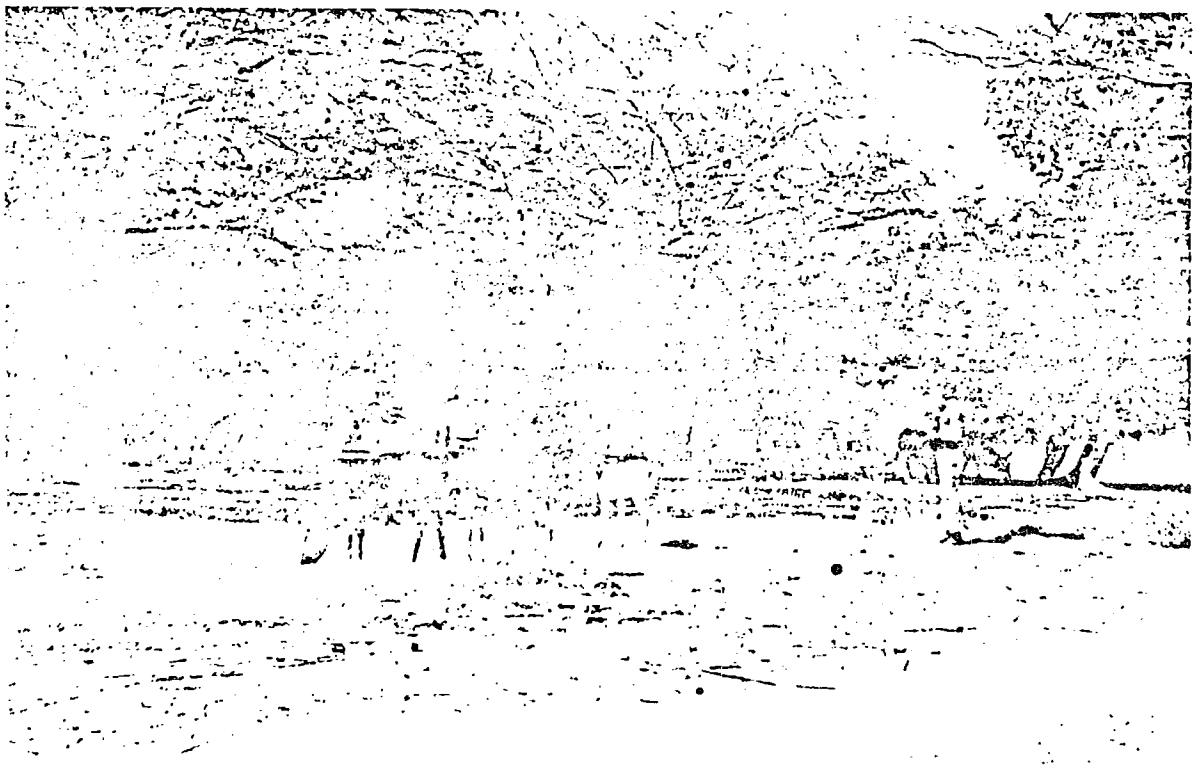


36. Multi-Use of an Established Tree Stand - 1

Sahelian wood stands serve many purposes. The following two photographs illustrate two vital uses. The wood that is being culled from this nine year stand of *Acacia scorpioides* is providing a nice revenue for its owner. A large limb has a market value equal to more than a skilled laborer's daily wage. Furthermore, the owner is culling and pruning, and not clear cutting. The stand is thus improved, while providing its owner with income and the land with cover.

37. Multi-Use of an Established Tree Stand - 2

As previously mentioned, animals depend upon woody perennials for much of their nutritional intake. Whereas the *Acacia albida* is a preferred species and the individual field trees allow a concentration of manure in the fields, larger wood stands or wind break systems also provide a source of forage.

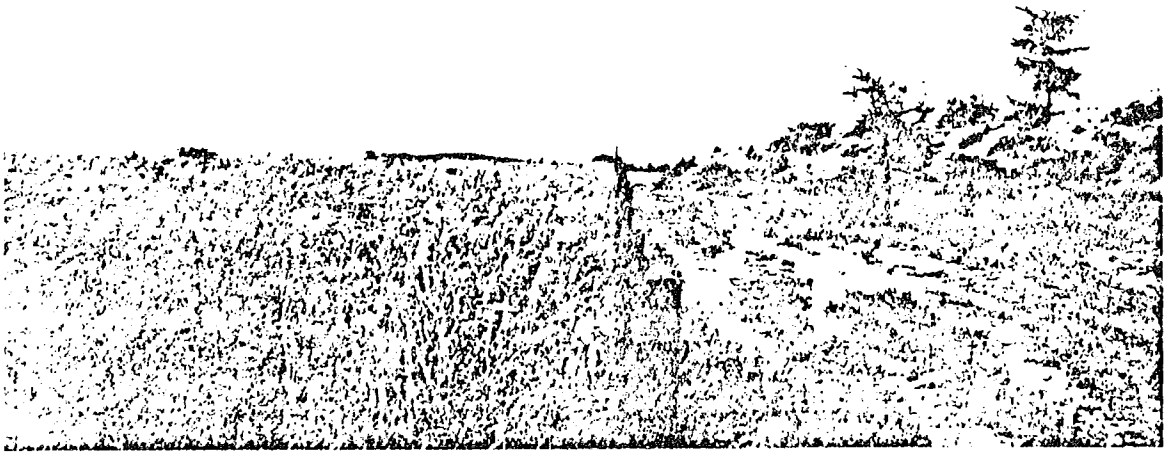


38. Field Protection

To protect their gardens and fields against browsing animals, many farmers use thorny branches. However, these branches are subject to termites, rot, trampling, and generally must be replaced every year. The replacing of these fences is labor intensive as well as destroying live vegetation. The planting of live thorny bush fences is a good alternative. In this photograph, Bob Kirmse, one of the CARE Project Managers, inspects a six-month old tree with a Mai-Lao gardener. The species used is the *Prosopis juliflora*, and the live fence is replacing dead thorns. This live fencing will be top-pruned to stimulate the intertwining of the lower branches.

39. Fenced Land (Demonstration of a Sustained Yield of Natural Resources from Managed Land)

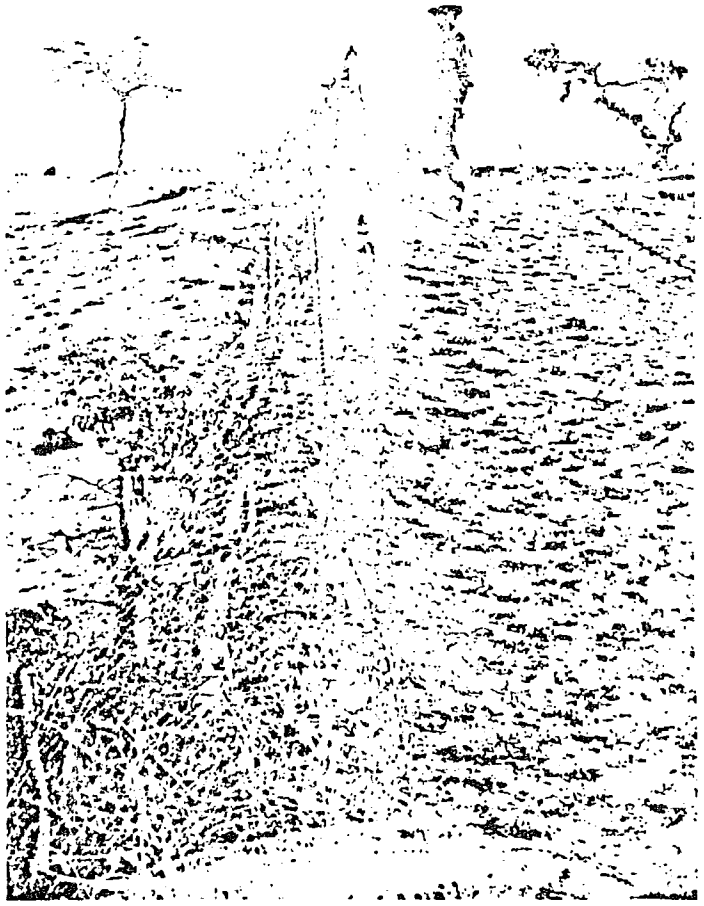
Fencing not only allows farmers and gardeners to protect their crops from browsing animals, but it also helps them protect their dry season lands from being over-grazed. This photograph illustrates the point of being able to harvest a crop throughout the year while allowing the soil to recover its fertility. The fence in the middle of the photograph separates a protected area from indiscriminate grazing. The high stand of grass, compared to the sparsely covered and eroding land on the outside, attests to the effective difference between managed and unmanaged land. During the recent drought, people came from 100 miles away to harvest this grass for their animals and for construction. Furthermore, this land had been useless before the fence was erected. Three years after the building of the fence, the land was highly productive crop land. In addition, trees were planted at intervals to provide for future firewood needs.



40. Mechanical and Living Barriers as Soil Conservation Measures

Soil erosion, wind or water, is a two step process: the displacement of the soil particles and the transport of the particles. In wind erosion, the displacement step generally involves particles of soil being moved on the surface or into the air (saltation - see appendix) and smashing into other particles. The force of the collision pulverizes the particles and sends many smaller particles into the air where they are carried upward and moved long distances or are carried a few feet and then smashed into another particle. There are several ways to combat displacement of soil particles. One of the most effective is to leave the field rough, either by plowing or by a mechanical or vegetative cover. (This is the reason a 'dirty' field should be encouraged throughout the dry season; a clean field encourages erosion; a field full of perennials or stalks collects dust and ashes).

Often cultivated land is left open much of the year. A barrier of some sort, every 50 meters, would help break the force of the wind or clean soil-laden wind of its load. In the beginning a mechanical barrier (a thorn fence is an example) would be needed. As the soil becomes stabilized around the barrier, it can be further stabilized by vegetative means. In the photo, a mechanical barrier is complemented by the live fence tree, Commiphora africana.



This technique is especially effective in areas where there are moving dunes. A dune is stopped from the windward side. Any barrier put up on the leeward side will be buried.

41. Soil Retention

Bob Kirmse, CARE Project Manager, illustrates the height of top-soil stopped by this Doum palm. Given that there are five or six shovelfuls of top-soil collected by this particular plant and that there are probably one hundred similar plants per hectare, naturally-occuring vegetation plays a vital role in soil retention.

42. Live Fencing - Commiphora africana

A Sahelian Farmer's Live Fence: This live fence of Commiphora africana was planted several years previously by a farmer who wanted to divert animal traffic. If first used with dead thorn fencing and correctly top-pruned, a good live fence lessens yearly labor by becoming stronger every year. Furthermore, a good live fence gives a farmer year-round control over his land which allows him to raise more perennials on marginal land or to regulate grazing.

36. Live Fencing - Parkensonia

Mr. Mike McGahuey and Mr. Robert Kirmse, CARE Project Managers, inspecting an eight-month old live fence/wind break planting at Mai-Lao.

IX. TECHNICAL APPENDIX

The techniques used in this project are simple but tested. CARE, in its basic approach to development programs, does not pretend to have the final solution. However, CARE and the Chadian Forestry Service recognize the availability of simple but workable techniques which can be brought to bear against some of the problems facing the Sahelian farmer.

In the Acacia albida project, in particular, CARE-Chad and the Chadian Forestry Department are employing some of these tried and true methods. These methods employ low and middle level technology and can be duplicated by the farmer himself.

The text of the manual reflects the basic philosophy that CARE's major role is the deployment of simple techniques geared to help the farmer help himself. However, most of the techniques are based upon a few physical phenomena, and it is the purpose of this appendix to expand upon a few of these phenomena which are at work in the Sahel.

Means of Expanding the Planting-Out Time-Frame

There exists a basic time frame within which the Sahelian farmer must plant out his seedlings. This time frame is determined by balancing the amount of available moisture in the soil with the earliest possible date for planting. Generally, the optimal time frame is two weeks.

Foresters have tried a multitude of ways to expand the time frame. One of the accepted methods is pre-planting cultivation. This is done either mechanically by tractor or manually with a shovel. These measures are very costly but they have become almost a standard practice, if a very high take and growth rate is expected.

The mechanical system generally involves a crawler-type tractor of the Caterpillar D-8 size, which rips the soil to a depth of 80 cms. The manual method employs shovels to pre-dig holes 1m x 1m x 80 cms, at each planting site. A catchment basin is then formed around each site to allow the accumulation of rainwater at the seedling site. In this way, rainwater infiltrates more efficiently and root development is faster.

Another measure in dry areas to increase moisture retention, is mulching. Plastic mulching is used more and more in agricultural projects in arid zones. Plastic sheathing is laid around the planting site to form a vapor barrier. The plastic is molded into a shallow funnel in such a way that the opening would be the neck of the tree. The opening of the "funnel" would be the lowest part of the plastic. Soil moisture, which evaporates upwards, is stopped by the plastic, condenses, and drains towards the opening of the funnel, finally concentrating around the root system.

A further method has been successfully used by Mamadou François, a Chadian Forestry agent, and David Blain, a Peace Corps volunteer, working in Chad. There are periods during the year when the soil moisture is within 50 cms of the soil surface, but where the surface is too dry to permit planting. In this case, a hole can be dug to the moist layer and refilled with wet soil. The take rate has been very good with this process. In many cases where ground water is available, this method may be used to extend the time frame of planting-out operations.

In short, Sahelian forestry is an intensive and costly process, but a very necessary one. The hope for the future lies in simpler methods which can be used by farmers that would allow fast production for a good profit. These methods will only be found by using the experience of the past and refining the current technology.

The Role of the Micro-Climate in the Sahel

The planting of a tree or a forest would probably have very little, if any, perceptible effect on the general climate. (There would probably be no more rainfall, for example). However, the micro-climate is greatly affected by vegetation or any covering of the soil, for that matter. Thus, within limits, the total rainfall is not nearly as important as what happens to the water once it reaches the ground.

Two things can happen to rainwater once it hits the earth's surface: it enters the ground or else it runs off and/or puddles. The main goal of this project as regards water retention is to maximize the amount of soil moisture available to food crops.

Vegetation (or any other material that covers the soil) generally favors conditions that would maximize the following: rainfall infiltration, moisture retention, and reduced transevaporation. Some of the reasons for

the improved conditions are: reduction of temperature, increase in relative humidity, and reduction of the 'splash effect'. The first two phenomena are obvious and need no explanation. The 'splash-effect' factor is very interesting and merits serious consideration.

The 'splash-effect' is only a relatively recently explored phenomena. The 'splash-effect' refers to the action that the raindrop has on the soil structure. This is as follows:

1. The raindrop hits the ground with a relatively large amount of kinetic energy;
2. The energy is transferred to the soil particles upon impact, and the soil particle is pulverized;
3. The smaller particles are washed into the voids of the soil where they eventually obstruct the water passages;
4. The water runs off and transports soil particles.

If there are no obstructions, the water can pick up large amounts of soil. Thus, not only is water lost to the soil, but the best soil is carried away. (Anyone who has walked in a field devoid of vegetation during a heavy rainstorm will have had the experience of being ankle-deep in water, but having footprints expose dry soil because none of the water has soaked past the first two centimeters of top soil). Studies in the Sahel and elsewhere have demonstrated that very little slope is necessary for water to run.

Vegetation has at least two effects on water erosion:

1. The 'splash-effect is minimized by breaking the force of the raindrop, and
2. The velocity of the running water is lessened.

Studies have shown that even physical barriers such as stubble diminish water erosion. However, a permanent vegetative cover would be the best shield against water loss and erosion.

Wind erosion is a second destructive force which can be reduced by some form of ground cover. The majority of air-borne soil originates from the interaction of one soil particle upon another in a phenomena known as 'saltation'. The process is as follows:

1. A particle of soil (generally between 0.01 mm and 0.05 mm) is pushed across the soil by the ground level wind;
2. If the force of the wind is great enough, the particle soon attains enough velocity and top-spin to be bounced into the air;

3. These air-borne particles generally rise to no higher than a meter, nor are they carried further than a few meters before they return to the ground and strike other particles;
4. The colliding particles are pulverised and some of the smaller particles are thrown into the air where they can be picked up by the wind and carried to high altitudes and for long distances. It is these particles which form the major part of air-borne soil.

Saltation can be reduced in several ways, but the common factor in all methods is attention to ground level wind velocity. The first step would be to reduce the velocity of the wind at ground level, so that it cannot roll the particles. The second step would be to reduce the velocity of the wind at the height of one or two meters from the ground so as to force it to drop air-borne soil particles before they are carried to the upper wind streams.

One method to disrupt the soil level velocity is to make the terrain as rough as possible. (Perfectly flat surfaces increase the number of soil particles which are exposed to the full force of the wind). Such techniques as stubble mulching are employed to disrupt the wind's full force. Another method is to spread heavy mulch or even grain stalks.

Once the soil is air-borne, higher barriers must be arranged to break the wind's velocity. These barriers can be mechanical or vegetative. Vegetative barriers can be trees planted at right-angles to prevailing winds, grasses that are planted in lines across the field or bushy plants which might or might not have economic value. In short, any existing vegetation which does not hamper regular agricultural activities should be left.

There are some very good examples of the effects of vegetation on the wind's ability to transport soil. Many farmers in the Sahel transplant the grass, Andropogen gayanus, along the borders of their fields. This grass is used in construction and it is harvested after the rains. The stalks are cut, but the roots and part of the stem are left and form a barrier which runs across the field. A small hill gradually builds up on either side of this barrier; these hills are formed from the saltating and other wind-borne soil particles. Other examples of vegetation trapping air-borne soil particles can be seen by examining individual plants, which have several shovelfuls of soil collected around their bases. The total amount of soil trapped by plants, per hectare, is significant.

Multiple Land-Use - Planning and Management

The Sahel has its own problems and advantages just as any other area in the world. One of the problems in Sahelian development programs is recognition of the particular needs of the people, and the unique solutions offered by the Sahelian climate and soils.

Some of the needs of the Sahelian people have been mentioned in the main text (food, fuel, fiber, shade, and animal forage). In short, most of the needs come from the land, and the rural economy depends upon the rational exploitation of the renewable resources of the land. One of the major goals of this project is to maximize the rational exploitation of these important resources.

One advantage that the Sahel has over many temperate climates is its twelve-month growing season. Furthermore, the average rainfall is generally over 500 mm. Therefore, for most perennials, Chad affords a year-round growing season without irrigation. The step that must be taken by the farmer is to recognize perennials as a renewable crop from which a year-round harvest is available. Furthermore, the process of rational exploitation allows the plant and the stand to improve itself.

The process of demonstrating the benefits of multiple land-use management can be undertaken in several ways. The most immediate way of demonstrating the profits of rational exploitation is to ask some of the following questions:

1. How far must one go to get fuel and firewood;
2. How much animal fodder is taken from perennials;
3. How important is shade?

A second demonstration of immediate benefits through rational exploitation can be made by initiating the following practices:

1. Pruning of shade and field trees to improve the trees <u>and</u> to provide fuel and firewood;
2. Processing of the seeds of species such as those found in the genus <u>Acacia</u> to allow the animals more nutrients from this high protein food; and
3. Developing of processes whereby grasses can be more tightly bound to facilitate transport (this would encourage farmers to harvest the stalks of millet and other grasses instead of burning all of the fields).

Most of the above uses and potential profits are well known to the farmer. The step of planting the perennials and actively raising them for several years before there is a harvest is the difficult step. Fortunately, there are some fast growing species which provide tangible benefits within a year. These species (Neem, Dalbergia, etc.) are not the best species for village wood use, but they are very fast growing and facilitate the demonstration of the feasibility of village and private wood plantations.