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ADOPTION POTENTIAL OF ROTATIONAL HEDGEROW INTERCROPPING IN THE HUMID LOWLANDS OF CAMEROON

Ann Degrande and Bahiru Duguma

Abstract

Shifting cultivation in the humid lowlands of Cameroon has been associated with declining soil fertility resulting in low yields of food and tree crops. Agroforestry and improved fallow systems such as hedgerow intercropping can play an important role in improving sustainable production on farmers' fields. Between 1988 and 1993 the International Centre for Research in Agroforestry Humid Lowlands of West Africa Programme (ICRAF-HULWA) in Cameroon evaluated the conventional hedgerow intercropping and, more recently (1994–8), rotational hedgerow systems. Farmer adoption has remained low. Based on continued monitoring of on-farm trials and a socioeconomic survey, three main reasons why farmers do not easily adopt the innovation were identified. Firstly, contrary to expectations, farmers indicated that land availability is not a problem and that they can acquire more land in the village if there is a need. Secondly, in the lowlands of Cameroon, soil erosion is not a major concern of farmers. Thirdly, farmers in the study zone do not feel that soil fertility is a major problem and are thus hesitant to invest in fertility management. Furthermore, farmers seem to be concerned about issues such as lack of marketing opportunities and shortage of cash to pay for health care and education, rather than the decline in soil fertility. However, recent experience with more flexible design and management of hedgerow intercropping and more targeted promotion of the technology has shown a growing interest of farmers to plant tree fallows. Consequently, further research should focus on diversification of the output of rotational hedgerow systems. The promotion of rotational hedgerow systems should target sites where farmers perceive land shortage and poor soils to be major problems.

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Acronyms

AEW	adult equivalent workers
ASB	Alternatives to Slash and Burn (IITA project)
HULWA	Humid Lowlands of West Africa
ICRAF	International Centre for Research in Agroforestry
IITA	International Institute for Tropical Agriculture
IRA	Institut de Recherche Agronomique
NGO	non-governmental organisation

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1 INTRODUCTION

In the humid lowlands of West Africa, food crop production by smallholders is based on traditional slash-and-burn agriculture or shifting cultivation. In this system, farmers slash the forest vegetation, burn the biomass and then crop for a year or two before abandoning the land to fallow. The length of the fallow varies from about three years in high population areas with relatively fertile soils to over ten years where population density is low and soil acidity is a major constraint. In recent years however, population growth has resulted in a reduction of the fallow length, leading to degradation of the natural resource base. This situation has been exacerbated by the sharp fall in the price of cocoa and coffee on the world market in 1985. To compensate for the lost income, farmers have intensified food crop production, thereby opening new crop fields from the forest.

In 1987, the International Centre for Research in Agroforestry (ICRAF) and the Institut de Recherche Agronomique (IRA) initiated a collaborative agroforestry research programme for the humid lowlands of West Africa (the HULWA Programme). Research activities focused on developing improved fallow systems that would increase food crop production and make it sustainable. It is known that improved fallows can play an important role in curbing deforestation. By shortening the fallow period of a field, farmers reduce the area of land a household needs and can thus help to reduce the slashing and burning of forest areas. Past research on alley farming and hedgerow intercropping has focused on biophysical evaluation on station, but still little information is available on farmer adoption of the technology. On-farm evaluation of hedgerow intercropping has been reported by Dvorak (1991), Swinkels and Franzel (1997) and Shepherd et al. (1997) for the highlands of Kenya and by Whittome (1994) for Nigeria and Benin. Adesina et al. (1997) studied the adoption of agroforestry technologies including alley cropping in the Northwest, Southwest, West, Centre and South Provinces of Cameroon.

The hedgerow intercropping prototype consists of planting leguminous trees (*Gliricidia sepium, Leucaena leucocephala* and *Calliandra calothyrsus*) at 4m by 0.25m. These trees are cut back for the first time after two years to a height of 0.05m. The tree branches are used for firewood and stakes, the remaining wood is burnt, while the prunings are applied as mulch. Crops are then planted in the alleys. To minimise competition above ground, trees are pruned twice during the cropping phase. After crop harvesting, a fallow period of one year is observed before the trees are cut back and crops are planted again. However, continuous on-farm evaluation and iterative modifications to suit farmers' needs and competence have resulted in a more flexible design, referred to as tree fallow (Kanmegne and Degrande, 1999). Here, farmers can adjust the tree planting density and the duration of the fallow period, as long as the tree biomass produced is sufficient to restore soil fertility.

In the humid lowlands of Cameroon, on-station trials showed the potential of hedgerow intercropping for soil fertility improvement. Over the past seven years, maize yield from the tree fallow plot was two times the yield from the continuous cropping with no hedge and 1.7 times the yield from the plot that was under natural fallow for two years (IRA/ICRAF, 1996). In spite of the excellent performance on station, on-farm evaluation of hedgerow intercropping in progress since 1988 revealed two facts. First, the biophysical performance of the technology was substantially inferior under farmer management. Maximum yield improvements were reported to be 0.4 times the baseline yield (IRA/ICRAF, 1996). Second, farmers' adoption of rotational hedgerow systems, as developed on station, was far below expectations.

The objectives of this paper are: (1) to describe farmers' evaluation of rotational hedgerows; and (2) to highlight key characteristics likely to influence adoption of this technology by farmers. The final goal of the study is to understand conditions under which improved tree fallows would be more attractive to farmers.

Biophysical characteristics of the study site

Project sites are located in Lékie and Mefou Departments, Centre Province and in the Department of Ntem, South Province. The altitude of the study area ranges from 600m to 800m above sea level. Though characterised as a peneplain, the southern plateau is an undulating terrain consisting of innumerable small hills 40–100m high. The climate is equatorial (Guinean type) with mean annual rainfall of 1600–1800mm and mean monthly temperature ranging from 19°C to 29°C. The rainfall is bimodal with a growing period of 270–365 days a year. The main dry months are between December and February and the minor dry season is from July to August. The soils are ferric acrisols, reddish to yellowish in colour with no pronounced profile differentiation and generally

with a clayey texture. Ferric acrisols are rich in aluminium and iron oxide and show very good physical but poor chemical properties (IRA/ICRAF, 1992). The vegetation in the humid lowlands of Cameroon consists of the tropical lowland rainforest to the south and west, and mosaics of forests and grassland to the north. Biophysical characteristics of the study sites are summarised in Table 1.

The major land use system found throughout the southern plateau is the cocoa/food crop/coffee system. In this system, food crop production is characterised by a fallow-based cultivation. Following the initial forest clearing and burning of the residues, the plot is planted with a climbing plant locally known as *ngôn* (*Cucumeropsis manii*), scattered maize and, in some cases, plantain. After harvesting *ngôn* and maize, the land is prepared and replanted with a mixture of other crops such as cassava (*Manihot esculenta*), cocoyam (*Xanthosoma sagittifolium*), maize (*Zea mays*), groundnut (*Arachis hypogeae*), plantain (*Musa acuminata*), sugar cane (*Saccharum officinarum*) or some vegetables (*Amaranthus* spp, *Vernonia calvoana*). All the seasonal crops are harvested as they mature, and the land is left to the annual crops such as cassava. Since no other activity (apart from the periodic harvesting of the cassava) is being carried out in such plots, the land starts the process of reverting to fallow with *Chromolaena odorata* appearing as a first coloniser. The livestock component is of minor importance and is characterised by free-roaming small stock (goats, sheep, pigs, and poultry). Diagnostic and design studies undertaken in 1988 identified the main production constraints in this system to be declining soil fertility, soil erosion on slopes, low yields of food and tree crops, poor management of cocoa plantations, labour constraints and destruction of crops by free-ranging small stock (Djimde and Raintree, 1988).

Socioeconomic characteristics of the study site

According to the 1994 census, the population of Cameroon is estimated at 13 million, of which 44 per cent reside in urban areas (World Bank, 1996). The annual growth rate is 3 per cent (World Bank, 1996), but there are major regional variations, for example, from 1.56 per cent in the south to 5.14 per cent in the north. According to the 1987 census, 46.4 per cent of the population is less than 15 years old, 50.2 per cent between 16 and 64 years, and 3.11 per cent over 65 years (Ministry of Environment and Forests, 1992). The total labour force in 1994 was estimated at 5 million, 37 per cent of which is made up of women. Seventy per cent of the active population is engaged in the agricultural sector, responsible for 32 per cent of the gross domestic product (World Bank, 1996). The geographical distribution of the population varies significantly among provinces and divisions. The national average population density in 1992 was 26 inhabitants/km^2. Population density is low (less than 12 persons/km^2) in East and South Provinces and high (50–100 persons/km^2) around Yaoundé. The capital Yaoundé is the most important urban area in the study zone. In densely populated areas, massive destruction of the natural resource base is evident. These areas also constitute a huge and expanding market with growing infrastructure. Low population areas are characterised by poorly developed infrastructure and uneven distribution of market outlets. One of the driving forces behind deforestation is access to markets, which means proximity to roads and towns (ICRAF, 1995). The major ethnic group in the project area is the Beti-Fang (including Eton-, Ewondo- and Bulu-speakers).

2 MATERIALS AND METHODS

In 1988, the first on-farm trials with hedgerow intercropping were established in the villages of Nkolfep and Abondo, about 40km north of the capital city,

Table 1 Biophysical characteristics of the IRA/ICRAF study sites, Cameroon

Parameters	Study Site: Yaoundé, Centre Province	Study Site: Ebolowa, South Province
Longitude	10°25' – 11°27' E	11° – 12° E
Latitude	3°51' – 3°53' N	2° – 3° N
Altitude	700m	615m
Temperature:		
mean annual	23.5°C	23.5°C
minimum	19.2°C	19.7°C
maximum	26.6°C	29.1°C
Rainfall (mean annual)	1600mm	1820mm
Relative Humidity (mean annual)	80%	80%
Rainfall Pattern	bimodal	bimodal
Soil Classification	Ferralitique (French) Acrisols (FAO) Humic Ultisol (US)	Ferralitique (French) Ferric Acrisols (FAO) Typic Kandiudult (US)
Vegetation	Secondary humid tropical forest	Humid tropical rainforest

Source: IRA/ICRAF, 1992

Yaoundé. The villages were selected through contact with the Testing and Liaison Unit of the National Cereals Research and Extension Project. The criteria used in farmer selection were availability of a suitable piece of land and willingness to participate. Since 1991, the programme expanded its on-farm activities to other villages; Nkoemvone, Biba and Mefoup in the South Province. A technology transfer project initiated in 1996 in collaboration with non-governmental organisations (NGOs) permitted to extend on-farm evaluation of rotational hedgerow intercropping over a wider range of biophysical and socioeconomic conditions and with a greater number of farmers (Table 2). The five different research sites are presented in Figure 1.

In the conventional hedgerow system (tested from 1988 to 1993), trees are planted in rows at 4m by 0.25m. A year later, the trees are cut back at 0.5m above ground level and the prunings are incorporated as mulch (Kang and Wilson, 1987). These management options were observed to have several shortcomings, including: (1) poor tree growth, thus low biomass yield due to early cut back and frequent pruning; (2) high labour demand and low flexibility in time of tree pruning; and (3) low impact on weed control and nutrient cycling due to absence of fallow phase (IRA/ICRAF, 1996). To address the above problems, the management of the conventional hedgerow system was modified in 1993. Some of the modifications were:

1. to ensure a minimum of two years' tree growth after planting before cutting back;
2. a fallow phase of at least one year alternating with a year of intercropping; and
3. to cut the trees at 0.05m instead of at 0.5m.

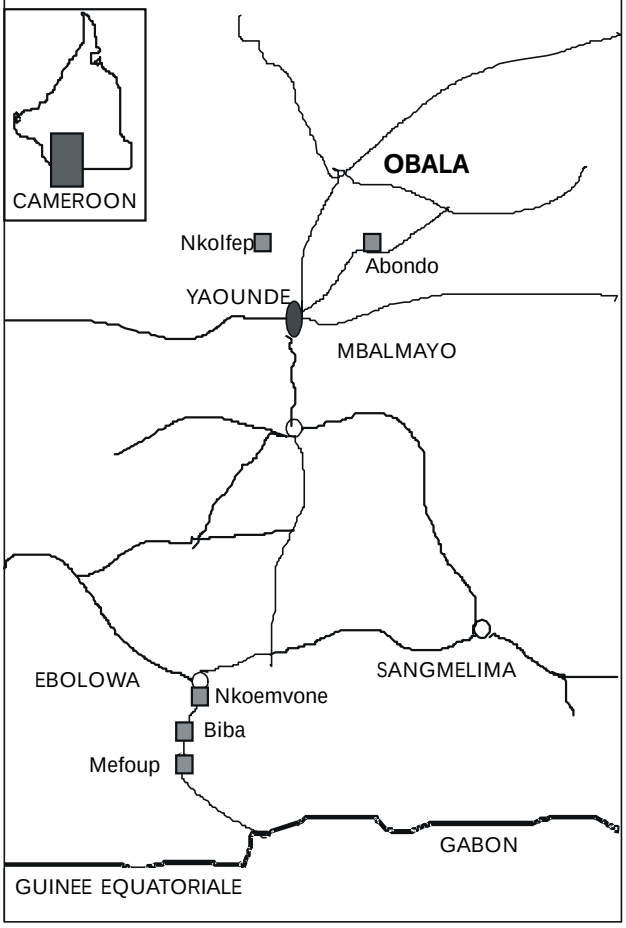
With these modifications the system was referred to as rotational hedgerow intercropping and tested on farmers' fields from 1994 to 1998. Biophysical and socioeconomic monitoring of on-farm trials included data collection on tree biomass, crop yield and labour. Periodic surveys were conducted with experimenting farmers to document their assessment of the technology to determine the management problems they experienced and to monitor modifications introduced. In 1995–6, a survey of 44 households involved in testing the technology was undertaken. The study provided baseline data on socioeconomic conditions of the households and revealed key characteristics that are likely to influence adoption of rotational hedgerow intercropping. The following hypotheses were formulated:

- Rotational hedgerow intercropping is more likely to be adopted where farmers perceive a need for soil fertility improvement and for various tree products.
- Security of land and tree tenure is necessary for farmers to establish hedgerows.
- Hedgerow intercropping is a labour-intensive technology and is highly inflexible in the timing of its labour requirements. It is thus unlikely to be adopted where labour is a limiting factor.
- One of the main benefits of hedgerows is soil and water conservation. This is particularly significant in moderately sloping land.
- Rotational hedgerow intercropping is known to suppress weeds effectively during the fallow phase. Adoption would thus be enhanced where weed invasion is perceived as a problem to cropping.
- Hedgerow intercropping has the disadvantage of providing limited early returns on investment. Unless short-term benefits such as fodder, fuel and stake provisions are of high value, farmers are unlikely to be willing to adopt it.

Table 2 Number of on-farm rotational hedgerow trials, Cameroon

Year	Number of trials
1988	6
1990	17
1991	22
1992	28
1993	36
1995	52
1997	120
1998	236

Figure 1 Location of the IRA/ICRAF research sites



- Rotational hedgerow intercropping is more likely to be adopted in areas of high land pressure.

3 RESULTS AND DISCUSSION

Demographic profile of trial households

Those households involved in the testing of rotational hedgerow intercropping are referred to here as trial households. Table 3 gives an overview of selected characteristics of the 44 trial households sampled. Our findings on household size, age, marital status and education level are similar to the results reported for the same region by Gockowski (1996) and also by a survey undertaken by the Alternatives to Slash and Burn Project of the International Institute for Tropical Agriculture (IITA) (ASB Project, 1996). Heads of trial households tend to be male, middle-aged, married, and father of about four children. According to David and Swinkels (1994), older male farmers with a wife and dependants have a number of characteristics that favour adoption of agroforestry technologies, such as family labour force, a long farming experience and a certain land tenure security. Sixty-five per cent of the heads of the trial households sampled had finished primary school and 32 per cent had attended some secondary school. Decisions related to farm operations are made either jointly by husband and wife (in 43 per cent of the cases) or by men alone (36 per cent).

Soil fertility and weed suppression

Although low soil fertility had been identified as a main problem in the area by researchers (ICRAF, 1988), farmers do not seem to perceive it as the most limiting factor. Fifty-two per cent of the households assess that more than half of their fields have good fertility and only four per cent think that the fertility status of more than half of their fields is low. Of the total cropping land available to the trial households, 51 per cent is evaluated by farmers as having good soil fertility, 34 per cent as average and 15 per cent as poor fertility. This can be explained by the fact that in most cases there is still a possibility to leave land in fallow for a reasonably long period (more than four years). The ASB survey indicated that 'poor soils' were identified as a major problem by only 32 per cent of the households whereas grass weeds and broad leaf weeds were listed as number one constraint in agricultural production by 69 per cent and 56 per cent of the respondents respectively. Pests and diseases were identified as the second most important problem by 42 per cent of the households (ASB Project, 1996). There is thus a divergence between the interests of the community and that of individual farmers: farmers do not see the need to adopt a technology that will not provide immediate advantages but will in the future have important benefits for the community. This has serious implications for the promotion of rotational hedgerow intercropping in the study area: emphasis on soil fertility improvement characteristics of the technology alone may not guarantee wide-scale adoption.

However, as weeds are identified as problem number one by farmers, the weed suppression characteristics of the technology should be given greater emphasis. Indeed, on-station and on-farm trials have demonstrated the potential of hedgerow intercropping to reduce weeds considerably (IRA/ICRAF, 1996). Likewise, 47 per cent of the experimenting farmers mentioned weed suppression as the main advantage of hedgerow intercropping.

Farmers also complain that soil fertility improvement accompanied by increased yields does not result in increased income because of inadequate market opportunities. Therefore, any investment in soil fertility improvement should be geared primarily towards the production of high value crops which are easily sold, and to areas with good market access. Similar behaviour is demonstrated in the current use of fertilisers: application of fertilisers is limited to high value crops such as tomatoes and okra and concentrated in areas close to urban markets.

Table 3 Overview of sample household characteristics

Average number of adults in household	4.1
Average number of children in household	3.7
Average age of head of household	50.3 years
Education level of head of household	Medium
Average farm size:	
under cocoa	4.56 ha
under food crops	4.05 ha
Labour-land ratio (AEW/total farm size)	0.5
Land tenure	Secure
Land availability	Medium
Labour availability	Medium, but low during clearing and weeding
Importance of livestock	Low
Erosion Risk	Low
Importance of off-farm cash income	Low
Investment capacity	Low
Access to market	Relatively good
Contact with extension services	Low

Land and tree tenure

Land tenure is known to play a significant role in the process of adoption of tree-based technologies such as rotational hedgerow intercropping (Lawry et al., 1992; Carter, 1996; Renolds, 1994). Ownership rights to land and trees are largely determined by customary tenure rules in the forest zone of Cameroon. Land is passed on from father to son when the father dies, and the tenure of these inherited lands is secured by customary law.

Lawry et al. (1992) concluded that a significant proportion of Cameroon is under favourable tenure systems: 46 per cent of the fields is under divided inheritance[1]. According to Tonye et al. (1993), 85 per cent of the forest zone of Cameroon falls under the category of inherited lands.

Seventy-five per cent of the households interviewed own the land on which they work. The others rent some fields or share a cocoa plantation with a father or brother. Consequently, adoption of rotational hedgerow intercropping may not be limited by land and tree tenure rules in the study zone. In fact, between 1988 and 1996, only one tree plot was abandoned because of land tenure problems.

Labour requirement

Hedgerow intercropping is a labour-intensive technology and is unlikely to be adopted where labour is a limiting factor (Carter, 1995). Labour peaks have been reported as one factor responsible for abandoning alley farms (Reynolds et al., 1991 cited in Renolds, 1994). Further, although modification in cutting the height of trees to 0.05m above ground level added some flexibility to the time of pruning, there are times that pruning coincides with other urgently needed farm operations. Monitoring of on-farm trials showed that although the first pruning after planting was carried out in 80 per cent of the tree plots, it was sometimes too late. On the other hand, the second pruning was neglected in 67 per cent of cases since farmers are very busy with weeding at that time and many think that the resprouts do not harm the crops.

The mean adult equivalent workers of the labour force per household was 4.34 (2.12 male and 2.22 female workers). The sexual division of the household labour force is thus approximately equally distributed. However, men and women have specific tasks and they work on different crops. From observations on farm we learned that 87 per cent of the tree plots was managed by men; in only two cases were the trees cut jointly by husband and wife. Ntone (1997) found three reasons why women do not easily adhere to the hedgerow intercropping technology. Firstly, the nursery establishment seems to be too labour demanding to fit in with the already overloaded work programme of rural women. Secondly, tree cutting is harsh for women and traditionally belongs to men's activities. Finally, although a woman has full usufruct rights on her husband's land, she needs his approval to establish hedgerows. Since trees remain on the land for a longer period and limit the flexibility of future land use allocations, men may not be willing to allow their wives to plant trees. Consequently, a woman is not likely to adopt hedgerow intercropping on her own because of the approval needed from her husband. Joint management, however, is quite common.

Farm operations are characterised by peak and slack periods in labour demand. Regarding labour shortage, 39 per cent of the households considers fallow clearing a major problem, while 16 per cent reported a shortage of labour for planting, and 17 per cent reported labour shortages for both weeding and harvesting (ASB Project, 1996). During peak periods, 54 per cent of the households undertakes farm operations through group work. Most of the households (86 per cent) hire labour for specific activities, such as the clearing of food crop fields and cocoa plantations and the harvesting of cocoa. Remuneration can be in kind (e.g. a meal and palm wine) or in cash (either paid immediately or after harvest). The hired labour usually comes from within the village.

From the above, it might be concluded that trial households not only have a considerable family labour force but also utilise labour groups and hired individuals to cover labour requirements during peak periods. If this was the case labour requirement for tree management should not be a constraint in the study area. Nevertheless, farmer assessment of the hedgerow intercropping technology showed that 57 per cent of the respondents complained about the time required for tree cutting. However it should be noted that laborious farm activities are not in themselves disincentives provided that farmers receive adequate benefits for their efforts.

Erosion risk

Theoretically, the adoption potential of rotational hedgerow intercropping is expected to be higher on sloping land (Sanchez, 1995). The survey results suggest that farmers do not consider erosion in the study area as a major problem. Seventy-five per cent indicated that less than one-quarter of their fields are on steep slopes and only four per cent reported that more than three-quarters of their fields are on steep slopes (steep, as defined by each farmer). In evaluating the technology, farmers did not mention erosion control as one of the benefits. The incentive to adopt hedgerow intercropping for the purpose of erosion control in the study villages thus appears to be low.

Land pressure

According to Carter (1995), hedgerow intercropping is more likely to be adopted in areas with high land pressure. In the study area, 64 per cent of the households reported that they have enough land to meet the needs of the family. Seventy-three per cent indicated that it is still possible to get more land in the village provided one has the means to buy or rent. In Ebolowa, one can easily be given a piece of land for short-term cultivation at no cost. Only 16 per cent reported that they had no possibility of acquiring additional land. Similar findings are also reported by IITA (1996), in which 74 per cent of the interviewed farmers confirmed that they have enough land if they wish to expand their farm activities. This proportion is higher in the Ebolowa area (89 per cent).

However, there is evidence that forest land is becoming scarce, especially near Yaoundé. Only two households cleared land from the forest after 1990, whereas 66 per cent reported that the last time they cleared forest land was before 1980. The average fallow period in Yaoundé area is estimated at four years. In Mbalmayo, farmers leave their land in fallow for five to six years and in the South Province the fallow period can reach seven years (IITA, 1996). The proportion of households with long-term fallow fields or forest land is lower in Yaoundé than in Mbalmayo and Ebolowa (ASB Project, 1996).

Importance of short-term benefits

Hedgerow intercropping has the disadvantage of providing limited early returns on investment. Farmers repeatedly complain about the fact that yield response only comes after several years. Unless short-term benefits such as fodder, fuelwood and stake provisions are of high value, farmers are unlikely to be willing to adopt this system (Carter, 1995).

The idea of creating additional incentives for the adoption of rotational hedgerow intercropping for fodder production may not be easy. The results of the survey showed that livestock production is a secondary activity for most trial households. The majority of sample households owns poultry (77 per cent), goats (66 per cent), pigs (34 per cent) and sheep (18 per cent), but the purpose of keeping livestock is mainly for home consumption, and to a lesser degree for cash income. The management depends on the kind of livestock. In all cases poultry are left to roam freely. Pigs (67 per cent) and goats (72 per cent) are kept in an enclosure or tethered during the rainy season. Even then, the animals often break loose thereby damaging crops planted near the homestead. Because of this, keeping goats is forbidden in some localities. In such cases, the farmers are forced to keep the animals in neighbouring villages where the rules do not exist or are not enforced. IITA (1996) reported that only four per cent of the households consider livestock as their most or second-most important activity.

The fact that trial farmers did not mention fuelwood as a benefit from hedgerow intercropping makes us think that firewood is still abundant in the study zone. Nevertheless, 67 per cent of the trial farmers said that they collect firewood from the pruned hedgerows. Taking into consideration the responsibility of women in fuelwood provision, emphasis on this aspect could draw the attention of women on rotational hedgerow intercropping. Furthermore, the production of stakes is well appreciated by experimenting farmers. The majority (80 per cent) used wood from hedges for staking, and it was mentioned as the main benefit by 47 per cent of the respondents.

Another side activity in rotational hedgerow intercropping, estimated to be very productive in Cameroon, is bee keeping for honey production. A good strategy to accelerate adoption of improved tree fallows, such as hedgerow intercropping, may be the promotion of apiculture in combination with tree planting. Currently, the IRA/ICRAF Programme in collaboration with two NGOs is testing the introduction of bee keeping as a side activity in improved tree fallows.

The role of research is to seek to diversify the products obtained from improved tree fallows and in particular to help farmers increase their cash income so as to overcome the disadvantage of limited early returns. The responsibility of researchers here is to make the information available to a large number of stakeholders – NGOs, national extension agents, policy makers and farmers alike. Unfortunately, extension services – which play a lead role in the promotion of new technologies – are not very active in the study zone. Only 32 per cent of the trial households reported to have limited contacts with extension agents.

Modifications and farmer expansion

Part of the on-farm research programme on hedgerow intercropping was the monitoring of modifications and innovations made by farmers. Farmers experimenting with the hedgerow intercropping together with researchers have adapted the technology so that it fits better into their cropping system (Kanmegne and Degrande, 1999). For example, the introduction of a fallow phase made the association with cassava possible[2] and selective burning of wood was a necessary step towards groundnut planting[3]. Other modifications observed in farmers' fields were the change in row spacing from 4m to 5m to be able to plant two rows of banana/plantain, associated with cocoyam, in between. On flat land, trees were also planted at 1m by 1m, which suppressed weeds more effectively and constituted an excellent woodlot for apiculture during the fallow phase.

With this added flexibility in technology design, a growing interest from farmers to plant hedgerows has been observed in recent years. The total number of hedgerows has increased from 57 in 1996 to 236 in 1998, and more NGOs and farmer associations are asking for tree seeds. Eighty-six per cent of the experimenting farmers said they were satisfied with the technology and 42 per cent had spontaneously expanded their tree plot. The increased spread of tree fallows in the humid lowlands of Cameroon in recent years is mainly due to efforts from NGOs which actively promote the technology by distributing tree seeds to interested farmers and by providing them with technical assistance. In villages where the technology was introduced a long time ago, new farmers are establishing hedgerows after having seen the results on neighbouring pilot farms.

Although most farmers indicate that the land they crop is still fertile because they have enough land to use natural fallow for soil fertility restoration, there is a growing awareness that this situation may not last for long as pressure on land increases. Consequently, more

and more farmers are willing to plant and manage leguminous trees in their food crop fields to maintain soil fertility.

4 CONCLUSION

In the humid lowlands of Cameroon, on-farm evaluation of hedgerow intercropping by the IRA/ ICRAF Programme has been in progress since 1988. Throughout the years the biophysical performance of the system was found to be inferior under farmer management on farm to that achieved on station. At the same time, farmers' interest in the technology was far below the expectations. This study tried to understand why farmers are hesitant to adopt the innovation and under which conditions the rotational hedgerow intercropping could be more attractive.

Farmer assessment of the technology indicated that improvement of soil fertility and reduction of erosion risk – two objectives for which the technology was originally developed – were not farmers' priorities. Indeed, the results of the survey showed that farmers in the study zone do not feel that soil fertility is a major problem and believe that land is still available. The findings also suggest that soil erosion is not farmers' first concern. Instead, farmers seem to be preoccupied with how to increase their cash income and their returns to labour. Consequently, to enhance adoption, research and extension should focus on short-term benefits of hedgerow intercropping, such as the potential to reduce weeds, provision of fuelwood and stakes, and bee keeping for honey production. Furthermore, the promotion of rotational hedgerow intercropping should target the following sites: where fallowing is still practised and pressure on land is increasing; where farmers perceive soil fertility as a major problem; and where market opportunities favour an intensification of the cropping system. Recent experience with more flexible design and management of hedgerow intercropping and more targeted promotion of the technology has showed a growing interest of farmers to plant tree fallows.

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ENDNOTES

1 Divided inheritance is the system where the land is divided amongst the sons after the father dies. We can say that this tenure system is favourable because the rights over the land and the trees are entirely transferred from the father to the sons. In areas of high population pressure, however, this systematic dividing of the land may lead to very small farms.

2 Cassava has a growing period of 6–12 months and is a heavy feeder. Traditionally, cassava is harvested progressively and the plot is left to fallow when all tubers are harvested, rendering a continuous cropping system inappropriate. The introduction of a fallow phase therefore offers opportunities to include cassava in the improved fallow system.

3 Groundnut is a short cycle crop, requiring a clean field denuded from all residues. Being a nitrogen-fixer, it does not respond to the application of nitrogen through mulching, but to the calcium and phosphorus that is released after the burning of residues (Kanmegne and Degrande, 1999).

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