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The Adoption and Dissemination of Fodder Shrubs in Central Kenya

By
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Abstract

Fodder shrubs have great potential for increasing the income of smallholder dairy farmers. This paper documents their uptake in central Kenya and the efforts of a range of institutions to promote their adoption. The successful dissemination of new knowledge-intensive practices such as fodder shrubs requires much more than the transfer of knowledge and germplasm; it involves building partnerships with a range of stakeholders, ensuring appropriateness of the practice, assisting local communities to mobilise resources, and ensuring participation of farmers' groups in evaluating the practice. The main challenge of the future is how to make such flows of information and germplasm self-sustaining.

Research findings

- *Fodder shrubs are an attractive alternative to the expensive protein concentrates that farmers feed their dairy cows and goats. They involve substituting small amounts of farm-sourced land and labour for farmers' most scarce resource: cash.*
- *The average farm in the Embu area can easily accommodate the 500 shrubs needed to supplement the basal feed of a cow, which is composed mainly of Napier grass and crop residues. This number of shrubs will allow a farmer to feed roughly 6 kg leaves per cow day to feed a dairy cow.*
- *The leaves can be used either as a substitute for dairy meal or as a supplement to it; in both cases they earn a household about $US 98–124 per year, following the year of shrub establishment.*
- *Fodder shrubs are a knowledge-intensive practice requiring, considerable training and facilitation, especially the first time farmers establish a nursery and again, about nine months later, at harvesting.*

Policy implications

- *Mechanisms are needed to enable government extension services and other development partners, such as non-governmental organisations (NGOs) and private enterprises, to incorporate successful new practices, such as fodder shrubs, from localised projects.*
- *Extension approaches are needed to enable farmers' groups, on their own, to access information on new practices. Governments and development partners should not see their role as simply transferring technology and information to farmers. Rather, they should focus on assisting farmers' groups to mobilise their own resources and enhance their ability to obtain information on improved practices from outside their villages.*
- *Assisting farmers to adopt new cost-saving technologies to produce a commodity that has serious marketing constraints is problematic. Improved milk marketing systems are needed in Kenya before technical innovations can achieve maximum impact.*

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Acronyms

CGIAR	Consultative Group on International Agricultural Research
DFID	Department for International Development
ICRAF	International Centre for Research in Agroforestry
ILRI	International Livestock Research Institute
KARI	Kenya Agricultural Research Institute
NAFRP	National Agroforestry Research Project
NARP	National Agroforestry Research Project
NGO	Non-Governmental Organisation
SLP	Systemwide Livestock Programme

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1 INTRODUCTION

The low quality and quantity of feed resources form the greatest constraint to improving the productivity of livestock in sub-Saharan Africa (Winrock International, 1992). Milk demand and production are concentrated around towns and cities where marketing costs are relatively low. Furthermore, farm sizes are also smaller in these peri-urban areas, exacerbating feed constraints. Fast-growing leguminous trees or shrubs (the terms 'tree' and 'shrub' are used synonymously in this paper) have the potential to alleviate farmers' feed problems. Leguminous trees and shrubs have root nodules that can often fix nitrogen from the atmosphere, making it available to plants. Fodder from these shrubs is rich in protein and, unlike grass species, the shrub leaves maintain their levels of protein even during the dry season. Moreover, farmers can use the shrubs for many other purposes – for hedges along boundaries and around the homestead, for prevention of soil erosion along contours and for fuelwood.

Since the early 1990s, the National Agroforestry Research Project (NAFRP), based at the Kenya Agricultural Research Institute (KARI) Regional Research Centre in Embu, has been actively testing *Calliandra calothyrsus* and other fodder shrubs around Embu. The project is jointly managed by KARI, the Kenya Forestry Research Institute, and the World Agroforestry Centre. By 1997, about 1000 farmers in the areas surrounding on-farm trial sites had planted calliandra but the project lacked the staff and resources required to extend the planting to other areas of the Kenyan highlands. A second project helped facilitate the scaling up of fodder shrub adoption throughout the central Kenya highlands, financed by the Systemwide Livestock Programme (SLP) of the Consultative Group on International Agricultural Research (CGIAR). The project ran from 1999 to 2001 and involved the World Agroforestry Centre, KARI, and the International Livestock Research Institute (ILRI).

The objective of this paper is to describe the development of fodder shrub technologies by researchers and farmers and the process of disseminating fodder shrubs to farmers throughout central Kenya. The paper highlights the importance of participatory approaches in the development of new fodder shrub practices and the key role of establishing effective partnerships to facilitate the scaling up process.

2 DESCRIPTION OF STUDY AREA

The coffee-based land-use system of central Kenya, ranging in altitude from 1300 m to 1800 m, is located on the slopes of Mt Kenya. Rainfall occurs in two seasons, March–June and October–December, and averages 1200 mm to 1500 mm annually. Soils, primarily Nitosols, are deep and of moderate to high fertility. Population density is high, ranging from 450 to 700 persons/km^2. In the Embu area, farm size averages one to two hectares. Most farmers have title to their land, and thus their tenure is relatively secure. The main crops are coffee, produced for cash, and maize and beans, produced for food. Most farmers also grow Napier grass *(Pennisetum purpureum)* for feeding their dairy cows and they crop their fields constantly because of the shortage of land. About 80% have improved dairy cows, 1.7 cows per family, kept in zero- or minimum-grazing systems. Milk yields average about 8 kg/cow/day and production is for both home consumption and sale (Minae and Nyamai, 1988; Murithi, 1998). Dairy goats, which are particularly suited to poorer households, are a rapidly growing enterprise.

The main feed source for dairy cows is Napier grass, supplemented during the dry season with crop residues, such as maize and bean stover, banana leaves and pseudostems, and indigenous fodder shrubs. Commercial dairy meal (composed mainly of maize bran, wheat bran, cotton seed cake, soybean meal and fish meal, and nominally 16% crude protein) is purchased by 45% of farmers to supplement their cows' diet (Murithi, 1998). The farmers complain that the price ratio between dairy meal and milk is unfavourable, that they lack cash to buy the meal, and that it is difficult for them to transport it from the market to their homesteads. Many also suspect its nutritive value, in part because of scandals in Kenya concerning fraudulent maize seed and agrochemicals sold to farmers (Franzel et al., 2002).

3 RESEARCH ON FODDER SHRUBS

Research on fodder shrubs by ILRI and KARI began in Kenya in the 1980s. The first on-farm trials in the Embu area were initiated by NAFRP scientists in 1991, testing three promising species: calliandra, *Sesbania sesban*, and *Leucaena leucocephala* to find out in which niches farmers preferred to plant the shrubs. Because of the limited size of the farms, farmers and researchers focused on integrating the shrub into the existing cropping system rather than planting the tree in pure-stand fodder banks. In farmer-designed and -managed trials, their choices included:

- *Planting the shrubs as hedges around the farm compound.* Hedges are a common feature of homesteads in central Kenya, and have traditionally been planted to relatively unproductive, non-browse species, to prevent free-ranging livestock from eliminating them. But livestock are now confined and there is great potential for replacing unproductive hedges with fodder hedges (Thijssen et al., 1993).
- *Planting along contour bunds and terrace edges on sloping land.* They thus help conserve soil and, if kept

well pruned, have little effect on neighbouring crops.

- *Intercropped with Napier grass*. Results from intercropping experiments show that introducing calliandra into Napier grass has little effect on the latter's yields (Nyaata et al., 1998).
- *Between upper storey trees*. which are commonly planted along boundaries The growth of fodder trees is hardly affected by taller species, such as *Grevillea robusta,* planted in the same line (NARP, 1993).

Pruning management has also been examined. The shrubs are first pruned for fodder nine to 12 months after planting, and pruning is carried out four or five times per year (Roothaert et al., 1998). Leafy biomass yields per year rise as pruning frequency decreases and cutting height increases but adjacent crop yields are negatively affected (ICRAF, 1992). The most productive compromise is probably in the range of four to six prunings per year at 0.6 to 1 m cutting height, which would yield roughly 1.5 kg dry matter (4.5 kg fresh biomass) per tree per year planted at two trees per metre in hedges under farmers' conditions. Thus a farmer would need about 500 shrubs to feed a cow throughout the year at a rate of 2 kg dry matter per day, providing about 0.6 kg crude protein. This amount would provide an effective protein supplement to the basal feed of Napier grass and crop residues for increased milk production. A typical farm of 1.5 ha could easily accommodate 500 shrubs without replacing any existing crops. For example, the farm would have available about 500 m of perimeter and several hundred metres in each of three other niches: along terrace edges or bunds, along internal field and homestead boundaries, and in Napier grass plots. As shrubs are planted at a spacing of 50 cm, only 250 m would be needed to plant 500 of them (Paterson et al., 1998).

Research on feeding calliandra has been funded by the Forestry Research Programme of the Department for International Development (DFID), UK. On-farm feeding trials have confirmed the effectiveness of calliandra as both a supplement to the basal diet and as a substitute for dairy meal. One kg of dry calliandra (24% crude protein and digestibility of 60% when fed fresh) has about the same amount of digestible protein as 1 kg dairy meal (16% crude protein and 80% digestibility) (Paterson et al., 1998); each increases milk production by about 0.75 kg (from 10.0 kg to 10.75 kg per day) under farm conditions, but the response is variable, depending on such factors as the health of the cow and the quantity and quality of the basal feed (Paterson et al., 1998). The effects of calliandra and dairy meal were found to be additive, suggesting that the two feeds are nutritionally interchangeable. Unfortunately, data are not available for constructing a response curve to show the effect of varying quantities of calliandra on milk production. Calliandra was also found to increase the milk production of dairy goats (Kiruiro et al., 1998).

Calliandra seedlings are raised in nurseries and transplanted following the onset of the rains. Experiments on seedling production have confirmed that the seedlings may be grown 'bare-root', that is, raised in seedbeds rather than by the more expensive, laborious method of raising them in polythene bags (O'Neill et al., 1997). Researchers are also conducting studies on other shrub species, exotic and indigenous, to help farmers further diversify their feed sources. In the late 1990s, two other species were introduced to farmers: *Leucaena trichandra*, an exotic, and *Morus alba* (mulberry), a naturalised species (that is, introduced over 100 years ago). Research continues on indigenous species but none has yet been identified that can be pruned intensively. *Desmodium intortum,* a herbaceous legume, has also been introduced to farmers with some success. Its chief disadvantage is that its biomass is not available during the dry season, when it is needed most.

4 FARMERS' ADOPTION OF CALLIANDRA

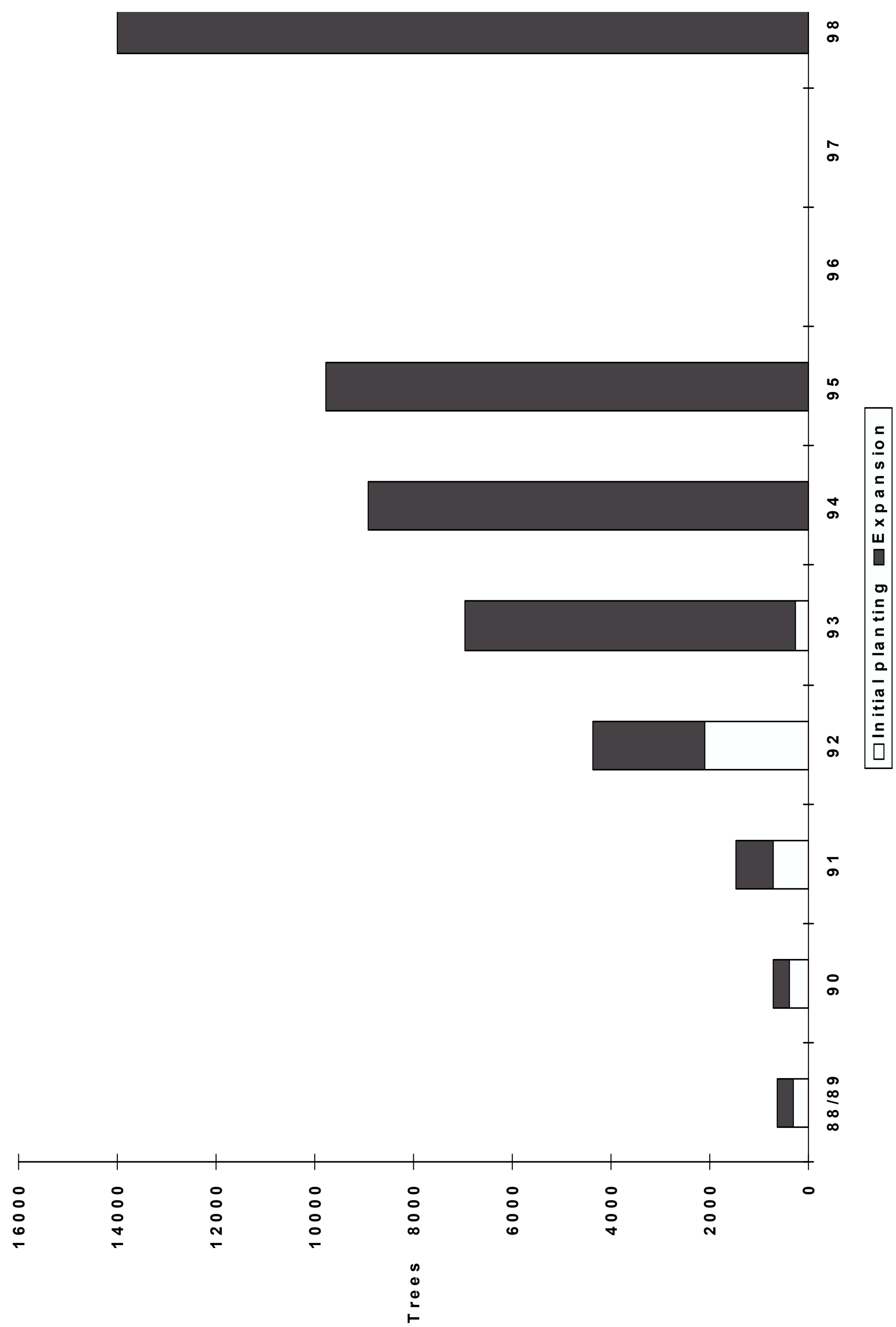
In the mid-1990s, research confirmed that farmers in the Embu area were adopting calliandra, expanding their plantings, and disseminating the practice to their neighbours (Franzel et al., 1999; Franzel et al., 2002). The first survey took place in 1995 and involved 45 randomly selected farmers from a list of those who had planted calliandra before 1993. About two-thirds had been involved in on-farm trials; the others had received planting materials from a development project or other farmers. The 45 farmers were surveyed again in 1998. Overall, the sample farmers had a somewhat higher income than other farmers in the area, and their farm size was about 20% larger.

Assessing adoption among farmers who participated in on-farm trials and special projects is sometimes suspect, as extensive contact and incentives may bias the farmers in favour of the technology being assessed. In this particular case, we feel that such concerns are negligible. None of the farmers received any incentives aside from free seed and seedlings. All received some advice about calliandra but, as the findings show, lack of information about calliandra was an important problem (one farmer somehow did not know that his calliandra leaves could be fed to livestock!). Monitoring and contact with research and extension varied; about half of the farmers had completed their trials by 1993 and afterwards had little or no contact with researchers.

Establishment and expansion of calliandra plantings

Farmers' first plantings of calliandra averaged 90 trees, of which 84 survived. The high survival rate, 93% (sd=13%), was consistent with data collected in farmer-managed trials in the same area and included some of the same farmers (NARP, 1993). Four-fifths of the farmers used potted seedlings to establish their first calliandra plantings, 16% established their own nurseries, and 4% direct seeded. First plantings occurred between 1988 and 1993 with over half taking place in 1992 (Figure 1). At the time of the first survey, most of the farmers had less than three years of experience planting calliandra.

Fig. 1 Numbers of calliandra trees planted by 45 surveyed farmers who started planting 1992/93 or earlier



Over four-fifths of the farmers expanded their calliandra plantings after their first planting (Table 1). Over one-third expanded twice, and 18% three or four times. As farmers expanded, the number of trees planted[1] per expansion increased, although because of the high variability, the differences were not statistically significant. In farmers' fourth and fifth plantings, the average number of trees planted was 54% higher than in their first plantings.

Table 1 Farmers' expansion of calliandra plantings, Embu, Kenya, 1995 (N = 45 farmers)

Planting	No. of farmers	Average no. trees per planting (s.d.)
Initial planting	45 (100%)	84 (65)
1st expansion	37 (82 %)	85 (54)
2nd expansion	16 (36%)	97 (99)
3rd and 4th expansion	8 (18%)	129 (143)

By 1995, the average number of trees per farmer had increased from 84 (s.d.=65) in their first planting to 218 (s.d.=225; median=166), an increase of over 2.5 times. The rate of increase slowed somewhat over the next three years; by 1998 farmers averaged 311 trees (Ondieki, 1999). The total number of trees planted by sample farmers increased from about 4000 in 1992 to over 14,000 in 1998 (Figure 1).

There were important differences in the method of planting and source of planting material between farmers' successive plantings (Table 2). Whereas the principal method in the first and second plantings was to use potted seedlings obtained from projects, the most important method in the third and subsequent plantings was to establish a nursery. Similarly, farmers' own trees and other sources (e.g., friends and relatives) replaced projects as the principal source of planting material beginning in the third planting. Of the 65 incidents of expansion, 33 involved planting seeds or seedlings obtained from projects, and 32, seeds or seedlings obtained from one's own farm or from other persons. By mid-1995, 36% of the farmers had established calliandra nurseries. Three-quarters of these used seed from their own trees.

The niches where farmers planted calliandra were sometimes determined by themselves and sometimes by researchers and farmers, as when an on-farm trial concerned a particular niche. Overall, the most common niches were in lines on contours, intercropped with food crops or coffee, and on homestead boundaries. When farmers chose the niches for planting, their most common choices were homestead boundaries, external boundaries, and in lines on contours (Table 3). Only two farmers planted calliandra in pure-stand fodder banks, reflecting their reluctance to allocate even small plots to calliandra.

Table 2 Planting methods and sources of calliandra planting material, Embu, Kenya, 1995 (N = 45 farmers)

Planting	Method (% of plantings)			Source of planting material (% of plantings)		
	Direct seed	Nursery	Potted seedlings	Project	Own trees	Other
1st	4	16	80	87	0	13
2nd	0	11	89	92	5	3
3rd	17	44	39	31	42	26
4th and 5th	0	60	40	44	44	11

Table 3 Niches where farmers chose to plant calliandra, Embu, Kenya,1995 (N = 35 farmers)

Niche	All plantings (Numbers and percentages of sample farmers)*	Plantings where farmer chose niche Numbers and percentages of farmers who chose niches (n=35)
In lines on contours	28 (62%)	8 (23%)
Intercropped with food crops or coffee	18 (40%)	6 (17%)
Homestead boundary	16 (35%)	11 (31%)
Intercropped in napier grass plots	15 (33%)	2 (6%)
External boundary	11 (24%)	10 (28%)
Internal boundary	9 (20%)	6 (17%)

* Percentages do not sum to 100 because farmers often plant in more than one niche. In some of the on-farm trials, farmers were asked to plant in a particular niche

There did not appear to be much association between uptake of calliandra and selected farm and household characteristics, but the assessment was constrained by the small size of the sample. Defining an adopter as a farmer who had expanded at least once and had more than 100 trees, 73% of the sample could be termed adopters. No association was found between adoption and farm size, wealth, size of farm adjacent to the homestead, or number of cows. There was a tendency for adoption to be associated with age; six of seven farmers under 30 adopted whereas only nine of 15 over 55 did so. The dairy enterprise's rank in importance among other enterprises was significantly associated with adoption at the $p<0.10$ level (Chi square test); the higher the rank of dairy, the more likely farmers were to adopt.

Management and uses of calliandra

Pruning methods were quite variable. The most common method was to cut periodically when the calliandra reached a height of about 1.0 to 1.4 m (before it becomes too difficult to reach and shades neighbouring crops too much), reducing the height to about 0.5 to 1 m. About 80% used pruning shears, which they owned already for use on their coffee and tea. A machete was used by 13%, who claimed that the stem was too thick to use shears. Primarily in order to save time 9% broke branches off by hand. Pruning shears are recommended because they make a cleaner cut, thus promoting regrowth and preventing disease and damage to the tree.

Farmers fed calliandra to a wide range of animals, 91% to dairy cows, 47% to goats, and 42% to heifers. Between 5% and 20% fed to each of the following: bulls, sheep, rabbits, calves and poultry, while 69% fed dry cows as well as lactating ones. This was often because they fed from the same trough and it was impractical to separate their rations. Nearly all farmers chopped calliandra before feeding, as recommended, as opposed to giving the branches to the cows to strip off the leaves. Over 90% mixed calliandra with Napier grass when feeding, about 44% also fed calliandra separately at times. Like dairy meal, calliandra is often fed during milking to help keep the cow still.

Only one farmer claimed to have fed calliandra to his cows throughout the year. On average, farmers fed it to their cows about one-third of the time, because the quantities they had were not sufficient for the whole year and shrub growth slows during the dry season. Only 12% reduced cutting during the wet season in order to have increased supplies during the dry season because failing to cut calliandra would increase its competition with crops. Three-quarters of the farmers fed their animals within an hour of cutting, in line with the recommendation to feed only fresh leaves (Roothaert et al., 1998). This recommendation has since been changed; recent research shows that calliandra can be fed either fresh or dried (Tuwei, in press).

Dairy meal was fed to their cows by 84% of farmers, though many said that, because of cash shortages, they did not feed continuously. Most (62%) used calliandra as a supplement to dairy meal, that is, they did not reduce their use of dairy meal when they fed calliandra. On the other hand, 27% used calliandra as a complete substitute for dairy meal and 10% as a partial substitute. Calliandra was claimed to increase milk production by 88% with 89% claiming their cows found it highly palatable.

Some farmers said they obtained other benefits from calliandra than increased milk production. In response to an open question, 24% said that fuelwood production was a benefit, 13% cited soil conservation, and 7% each cited calliandra's beautiful appearance, money saved by not having to buy dairy meal, and a creamier milk texture (researchers have found that calliandra increases the butterfat content of milk). The only negative aspects cited were scales (18%), a pest that is more common during the dry season, and that calliandra reduces the yield of adjacent crops (7%).

The farmers varied considerably in the way they used the seed produced by their trees. Seed was harvested by 40%; those that did not do this cited a lack of interest or knowledge about propagation techniques. One-third of the farmers gave seed to others; each gave to an average of 13 other farmers (this figure is skewed upwards because two farmers gave seeds to 110 farmers – the median number of persons given seed was four). Two farmers sold seed or seedlings to other farmers. Two-thirds had left some trees to seed at the time they were interviewed, indicating their strong interest in expanding calliandra production or in distributing seed.

5 DISSEMINATION OF FODDER SHRUBS: ACHIEVEMENTS AND IMPACT

The NAFRP helped farmers' groups in the Embu area set up 14 calliandra nurseries in 1997, 26 in 1998, and 12 in 1999. But extension work was outside the project mandate; therefore, the new project financed by SLP recruited a dissemination specialist in 1999 to scale up the use of fodder shrubs in central Kenya (ILRI, 2000). The scaling-up task was not exclusively to transfer knowledge of fodder shrub technologies and seed to new areas but, equally important and more time-consuming, (1) to build partnerships with a range of stakeholders in new areas, (2) to assess whether feed shortage was a felt problem among farmers, and consequently gauge their interest in planting fodder shrubs and determine whether the shrubs were appropriate to their environment, (3) to assist farmers' groups and communities to effectively mobilise local and external resources for establishing calliandra nurseries, and (4) to ensure the effective participation of farmers' groups and stakeholders in testing, disseminating, monitoring and evaluating the practice. These tasks were considered vital to ensuring that scaling up would be sustainable once the project was implemented (Wambugu et al., 2001).

Initially, project staff reviewed secondary information and results of farmer surveys to assess appropriate areas for fodder shrubs. Potential collaborating organisations across seven districts (a district comprises roughly 2000 to 4000 km^2 and 200,000 to 500,000 people) were identified, including government departments, NGOs, churches, and community-based organisations. Fortunately, most were already using participatory research and development methods and confirmed that farmers they worked with had critical problems feeding their dairy cows and were interested in planting fodder shrubs. Farmers in a few areas, such as those focusing on irrigated vegetable production, were not interested in planting fodder trees.

Project activities extended across seven districts but were focused in clusters within each district to reduce costs and to facilitate monitoring and the exchange of information among groups. The project dissemination specialist identified interested farmers' groups through Ministry of Agriculture extension agents and other collaborators. Most of the groups were already in existence before the project, promoting such activities as keeping dairy goats, handicrafts, domestic water tanks, soil conservation, organic farming or shrub nurseries. Most (76%) of the groups included both men and women; 15% were women's groups and 9% were men's groups (Table 4). Group size ranged from four

Table 4 Groups establishing fodder shrub nurseries, central highlands of Kenya, 2000

Farmer gender	No.	%	Type of group	No.	%
Female farmers	1560	60	Mixed groups	115	76
Male farmers	1040	40	Women's groups	22	15
Total	2600	100	Men's groups	13	9
			Total	150	100

to 50 and averaged 17 members. Women accounted for 60% of all group members.

Meetings were held with the groups to discuss the problems they had in feeding their cows and to explain the costs, benefits and risks of planting fodder shrubs. Farmer visits were arranged to see farmers in the Embu area who had already had several years of experience in growing and feeding calliandra to their dairy cows and goats. Most of the farmers' groups paid for their own transportation and subsistence costs on these visits, collecting funds from members and hiring local buses or using public transportation. Seeing and discussing calliandra with experienced farmers was an effective means to promote calliandra planting and to provide a forum for farmers to learn about its growth, management and use. The tours involved 420 farmers from 25 groups and 20 extension staff.

For areas where farmers were interested in fodder trees, project staff and partners discussed the terms of collaboration and each party's role was made explicit: SLP staff would initially provide the training and seed but after two to three years the partner organisation would take over these functions. Joint work plans were then developed, which clearly indicated a schedule of training events and follow-up activities. Needs assessments were undertaken to determine farmers' knowledge and skills and to ensure that training would build on farmers' indigenous knowledge. Once farmers were trained to establish nurseries, they, in turn, trained their neighbours.

Between 1999 and 2000, the project dissemination specialist assisted staff of the following organisations to help farmers establish nurseries: the provincial administration in two provinces, three departments of the Ministry of Agriculture and Rural Development, one international NGO, four local NGOs, the extension service of a private company, two church extension services, 10 community-based organisations and 150 farmers' groups. Staff also helped schools and churches establish 10 nurseries on their compounds to serve as demonstrations.

Nurseries had to be located close to a permanent water source; this condition limited the number of nurseries and the spread of the practice. Group members divided the labour among themselves and shared the seedlings produced. Most groups preferred to grow their seedlings using the 'bare-root' method rather than in polythene bags. The former have lower survival rates but are much less expensive to produce, as bags are expensive and filling them with soil is laborious. So long as farmers had access to water, they were able to establish nurseries successfully. They also needed some training, especially with establishing the nurseries and with harvesting. (In the following year, most of the training was provided by the previous year's trainees.) In a survey of 75 group nurseries during the first year of project activities, 1999, 58 (77%) were rated as 'good' or 'fair', indicating the groups' ability to produce high-quality seedlings.

By the end of 2000, the 150 groups had developed 250 nurseries involving over 2600 farmers (Table 5). On average, farmers each transplanted about 245 calliandra seedlings, of which about 156 (64%) survived. Drought was the main cause of the high mortality. Rainfall was less than normal for three consecutive seasons: the short rains of 1999 and the long and short rains of 2000.

Selected group members were trained in how to produce and distribute seeds. Calliandra begins producing seed in its second year but unfortunately they produce relatively little and collecting it is laborious. Some farmers and private nurseries have begun selling calliandra seed and seedlings, and the numbers doing so are likely to increase as production and demand for the shrubs increases.

The SLP project also started disseminating other fodder legumes; farmers in 80 groups have planted *L. trichandra,* 70 groups have planted mulberry, and 13 groups have planted *Desmodium intortum.* Farmers value diversification because it reduces the risk of pest and disease attack and improves feed quality. In addition, the project's dissemination approach has been adopted by other partners, who are disseminating improved mangoes, climbing beans, and new maize and potato varieties to the same farmers' groups.

6 FARMERS' INNOVATIONS AND PROBLEMS

Informal monitoring takes place in which farmers and extension staff provide feedback to researchers on their progress and problems. In one case, feedback on a farmer innovation has resulted in a change in extension recommendations. Farmers in Kandara Division, Maragua District, conducted experiments on soaking calliandra seeds before planting and found that seeds soaked for 48 to 60 hours had higher germination rates than those soaked for the recommended 24 hours. Researchers at KARI-Embu confirmed the farmers' findings and extension staff now recommend the longer soaking time.

Severe drought and poor distribution of rainfall during 1999 and 2000 increased the mortality of seedlings in the nurseries and shrubs in the field. Lack of seed was also a critical constraint limiting expansion, especially in areas where fodder shrubs are not found. Infestation by crickets, hoppers and aphids has also led to a significant loss of seedlings. These pests are particularly damaging during dry periods. The high turnover among staff of the Ministry of Agriculture, poor morale, and the lack of resources such as transportation have also limited success. The SLP project occasionally assisted ministry staff with transportation and subsistence allowances, which greatly increased

Table 5 Expanding numbers of fodder shrub nurseries, central highlands of Kenya

Season and year	No. of districts	No. of farmers' groups	No. of nurseries	No. of farmers
1999 long rains	2	12	12	220
1999 short rains	6	117	180	2037
2000 long rains	7	150	250	2600

staff motivation. Finally, the poor performance of the milk market in many areas has had a negative influence on adoption. Following the collapse of the main milk marketing system in Kenya in the late 1990s, the private sector has been slow to fill the gap and many farmers currently have problems marketing their milk.

7 ASSESSING ECONOMIC IMPACT AND POTENTIAL

In 2001, farmers in central Kenya who planted about 500 calliandra shrubs earned an additional $US98–124 per year from their dairy enterprises, beginning in the second year after planting (Appendix 1). The benefits were the result of either using fodder shrubs to increase their milk production or in savings from reducing their purchases of dairy meal. The average household has about 1.7 cows per farm, thus the potential increase in earnings per household is around US$189, an increase of approximately 10% in household income.

Fodder trees appear to be appropriate for smallholder dairy farmers throughout the highlands of eastern Africa – calliandra, for example, can grow at altitudes between sea level and 1900 m, requires only 1000 mm rainfall, can withstand dry seasons up to four months long, and is suitable for cut-and-carry feeding systems or for grazing systems (Roothaert et al., 1998). It is also suitable for dairy goat production, which is growing rapidly in Kenya. The potential impact of fodder trees thus appears to be very large. If all 625,000 smallholder dairy farmers were to adopt calliandra or similar fodder shrub species, the benefits would amount to about US$118 million per year.

Fodder trees also have important potential in the large-scale dairy sector, which supplies 30% of Kenya's milk. Moreover, fodder trees are being planted by dairy farmers at numerous other sites in east and southern Africa. Over 500 farmers in Uganda, Tanzania and Zimbabwe have adopted fodder trees. They are also being planted in Rwanda, Ethiopia, Malawi and Zambia. Results are promising.

8 FACTORS CONTRIBUTING TO SUCCESS AND SOME CHALLENGES

Several factors have contributed to the achievements thus far:

- The demand among farmers for fodder shrubs was high, mainly because the shrubs save cash, the farmers' scarcest resource, and require only small amounts of land and labour, which can be sourced from within the household.
- The project area is noted for the dynamism of its farmers, and access to markets is relatively easy, enhancing the adoption of new practices.
- Participatory methods were used in designing the fodder shrub technology. Initial on-farm trials were farmer-designed and -managed, permitting farmers to plant the trees in niches of their choice and to manage them as they saw fit.
- Because the projects promoting fodder trees worked through partner organisations instead of directly with farmers, they were able to build on local organisational skills and knowledge and reach far more farmers than would otherwise have been possible.
- Dissemination through farmers' groups instead of individual farmers economises on scarce training skills and resources. In addition, working with groups ensures greater farmer-to-farmer dissemination and exchange of information.
  - The strong partnership between researchers, extensionists and farmers facilitated the flow of information among the three.

Nevertheless, several critical challenges remain:

- Despite the spread of fodder shrubs documented in this paper, as of early 2003, only 23,000 (4%) of Kenya's 625,000 smallholder dairy farmers have planted them. Further scaling up is taking place, focusing on institutions working in areas of the country where smallholder dairy farmers predominate. The World Agroforestry Centre and the Oxford Forestry Institute (UK) are currently implementing a project funded by the Forestry Research Programme of DFID to scale up the impact of fodder trees in four countries of East Africa: Kenya, Uganda, Rwanda and Tanzania. The project supports extension facilitators working at eight sites across the four countries. At each site, the facilitators assist a range of partners, including government extension staff, NGOs, churches, farmers' associations, and private companies to promote fodder trees. The project also conducts studies on the adoption, impact and spread of fodder shrubs, and the promotion of private seed production and distribution systems.
- Commercial seed production and distribution are emerging in project areas, but it is not clear if the practice, and germplasm to support it, will spread by itself into new areas. Greater emphasis is needed on promoting community-based seed production and distribution through a range of partners: farmers' groups, individual seed producers and private nurseries.
- Greater diversification of fodder shrubs is needed to reduce the risk of pest and disease attacks and improve feed quality. Greater emphasis is needed on screening indigenous species. KARI-Embu has the lead role in evaluating fodder trees in Kenya.

- Finally, experience confirms that successful scaling up of a new knowledge-intensive practice such as fodder shrubs requires more than transferring seed and knowledge about it. Rather, facilitators need to build partnerships with and among a range of stakeholders, ensure farmers' interest in the practice and its appropriateness to their conditions, assist farmers' groups and communities to mobilise local and external resources effectively, and ensure the effective participation of farmers' groups and stakeholders in the processes of testing, dissemination, and monitoring and evaluation. The critical question is when, and under what circumstances, the spread of the practice, i.e. of information and germplasm, will become self-sustaining. Mechanisms are needed to enable government extension services and other partners, such as NGOs and private enterprises, to incorporate successful new practices and dissemination approaches, such as fodder shrubs, from localised projects. We are working to promote the sustainability of the fodder shrub enterprises in several ways:

- promoting private-sector seed production and marketing
- facilitating private institutions, such as dairy marketing firms and agricultural stockists to promote fodder shrubs
- determining the role of farmer-to-farmer dissemination in spreading the practice and assessing ways that we can promote it
- assisting farmers' groups to mobilie their own resources and obtain information on improved practices from sources outside their villages

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ENDNOTE

1 Number of trees survived is used instead of numbers of trees planted, because in many cases the farmers could not remember how many trees they had planted, whereas surviving trees could be counted.

APPENDIX 1 ECONOMIC ANALYSIS OF FODDER SHRUB PRODUCTION

Partial budgets were drawn up to show the effects of using fodder shrubs on farmers' net income under two scenarios: using calliandra (1) as a supplement to the normal diet and (2) as a substitute for purchased dairy meal. The base analysis assumes a farm with 500 trees and one zero-grazed dairy cow, and covers a five-year period. The benefits included in the analysis are the effect of calliandra on milk production (in the supplementation case) and the cash saved by not purchasing dairy meal and interest on cash freed up (in the substitution case). Costs are those of the seedlings and labour for planting, cutting and feeding calliandra in 2001. Coefficients, prices, and sources of data used in the economic analysis are shown in Table A1.

Partial budgets for calliandra as a supplement to farmers' basal feed and as a substitute for dairy meal are shown in Tables A2 and A3. Tree establishment costs (including the costs of seedlings and planting) are modest, US$2.31/500 trees. Beginning in the second year, harvesting and feeding 2 kg dry calliandra per day as a supplement throughout the lactation period increases milk production by about 450 kg/yr, an increase of about 10% over base milk yields. Incremental benefits per year after the first year are over 12 times higher than incremental costs. The net present value (NPV) assuming a 20% discount rate is US$206.50. Net benefits per year after the first year are $96.01.

In the partial budget assessing calliandra as a substitute for dairy meal, establishment, cutting and feeding costs are the same as in the preceding analysis. By feeding calliandra, the farmer saves the money he would have spent buying and transporting 730 kg dairy meal during the year. Incremental benefits per year after the first year are over 14 times higher than incremental costs. Milk production does not increase but net benefits are slightly higher than in the supplementation case. The NPV assuming a 20% discount rate is $262.27. The net benefits per cow per year after year 1 are $123.73. Therefore, using calliandra increases farmers' annual income by about $96 to $124 per cow per year after the first year, depending on whether the farmer is supplementing or substituting. As the average farmer owns 1.7 cows, calliandra has the potential to increase a farmer's income by around $163 to $211 per year, representing an increase of about 10% in total household income (Murithi, 1998).

The partial budget was also calculated for the years 1996–8 and net benefits after year 1 ranged from $94

Table A1 Coefficients and prices used in the economic analysis

Items	Values	Data sources
Coefficients		
Period of analysis	5 years	Assumption
Lactation period	300 days	Assumption
Days fed calliandra	365 days	Assumption
Days fed dairy meal	365 days	Assumption
Calliandra quantity fed per cow per day	6 kg fresh (equiv. to 2 kg dry)	Assumption
Dairy meal quantity fed per cow per day	2 kg	Assumption
Milk output per day from 1 kg dry calliandra	0.75 kg	Paterson *et al.* 1996c
Milk output per day from 1 kg dairy meal	0.75 kg	Paterson *et al.* 1996c
Calliandra leafy biomass yield per tree in year 1	0 kg	Farmers' experience
Calliandra leafy biomass yield per tree per year, years 2-5	1.5 kg (dry)	Paterson *et al.* 1996c
Trees required to feed 1 cow per year	487	Computed from above.
Tree survival rate	80%	Survey data
Calliandra planting labour	20 trees per hour	Farmers
Calliandra cutting and feeding labour	15 minutes per day	Farmers
Discount rate	20%	Assumption
Interest on capital freed up by using calliandra instead of purchasing dairy meal	Capital tied up for an average of 2 weeks, 20% annual interest rate	
Prices		
Dairy meal	$ 0.201/kg	Market survey, 1996–1998
Transport of dairy meal	$ 0.008/kg	Market survey, 1996–1998
Seedling cost (bare-rooted)	$ 0.526/100 seedlings	Swinkels, Rob (unpubl. data from on-farm trial)
Labour cost	$ 0.118/hour	Farmers, 1996–1998
Milk price (farm gate)	0.296/kg	Farmers, 1996–1998
Annualised value of fixed cost for seedling establishment for 500 trees	$ 2.18	Use of capital recovery formula* (Spencer *et al.* 1979)
1 US$ = 59 Kenya Shillings		Average exchange rate, 1996–1998

* K=(rv)/(1-(1=r)$^{-n}$) where K is the annual service user cost, V is the original (acquisition) cost of the fixed capital asset, r is the discount rate, and n is the expected life of the asset. This procedure allows both the depreciation on capital and the opportunity cost of capital to be costed out.

to $151, depending on the year and whether the farmer was assumed to be supplementing or substituting (Franzel et al., 2002).

The analyses confirm that the costs of establishing, maintaining, and feeding calliandra are low. In both the substitute and supplement scenarios, farmers recover their costs very quickly, in the second year after planting. In order to break even, a farmer using calliandra as a supplement needs to obtain only 0.08 kg of milk from 1.0 kg of calliandra (dry), rather than the 0.75 kg milk per kg (dry) of calliandra obtained in on-farm trials and assumed in the analysis.

Several intangible or otherwise difficult to measure benefits and costs have been omitted from this analysis. Calliandra provides benefits to some farmers as firewood, in erosion control, as a boundary marker, a fence and as an ornamental. It also increases the butterfat content of milk, giving it a richer taste and creamier texture. When used as a supplement, calliandra may improve animal health and fertility and reduce the calving interval. Finally, several farmers noted that calliandra had important benefits relative to dairy meal: it was available on the farm, cash was not needed to obtain it, and its nutritional content was more reliable than that of dairy meal. These views support the thesis that farmers prefer enterprises and practices that do not rely on uncertain governmental or market mechanisms (Haugerud, 1984).

The main costs not assessed are the opportunity cost of the land occupied by the trees and the effect of reducing yields of adjacent crops. However, these are likely to be relatively low, especially when calliandra replaces or is added to an existing hedge or bund, is pruned frequently, or when calliandra hedges border on homesteads, roads, paths or external boundaries.

Sensitivity analysis was conducted on the 1996–8 results to determine how changes in key parameters would affect the results (Franzel et al., 2002). A 30% reduction in the milk price would reduce the NPV by 33%. However, using calliandra would still be profitable. In the substitute scenario, changing the milk price would not affect the profitability of calliandra relative to dairy meal. A change in the price of dairy meal does not affect the use of calliandra as a supplement. However, in the substitution scenario, a 30% increase in dairy meal price raises the NPV by 32%. A reduction of price by 30% reduces the NPV by 32%. A higher discount rate, 30% instead of 20%, would reduce the NPVs of calliandra in both scenarios by 23%. A 30% increase in labour costs, however, would have little effect, reducing NPVs by less than 5%. If one assumes that 1 kg dairy meal or 1 kg dry calliandra gives 0.5 kg milk instead of 0.75 kg milk, the NPV in the supplement scenario decreases by 37%. Overall, the sensitivity analysis suggests that the net benefits of using calliandra as a supplement or as a substitute are very stable. Despite the range of negative situations tested, net present values and net benefits remain positive.

Table A2 Partial budget: Extra costs and benefits of using calliandra as a supplement for increasing milk production ($/yr, 2001)

	Extra cost		Extra benefits		Net benefit
Year	Item	$	Item	$	$
1	Tree seedlings	2.31			-2.31
	Planting labour	3.29			-3.29
	Subtotal	5.60		0	-5.60
2	Cutting/ feeding labour	10.00	450 kg extra milk	107.88	97.88

Years 3–5 same as year 2
Net present value at 20% discount rate = $206.50 per year
Net benefit per year after year 1 = $ -97.88
AnnualISed net benefit, treating establishment costs as depreciation = $ -94.14

Note: Base farm model: The farm has 500 calliandra trees and one dairy cow. The cow consumes a basal diet of 80 kg Napier grass per day and produces 10 kg milk/day. Two-thirds of the trees are planted on homestead and external boundaries; one-third are planted on contours with Napier grass.

Table A3 Partial budget: Extra costs and benefits of substituting calliandra for dairy meal in milk production ($/yr, 2001)

Year	Item	$	Item	$	US$
1	Tree seedlings	2.31		0	-2.31
	Planting labour	3.29			-3.29
	-Subtotal	5.60			-5.60
2	Cutting/feeding labour	10.00	Saved dairy meal cost	129.70	
			Saved dairy meal transport	4.02	
			Interest on capital freed up	0.90	
			-Subtotal	133.74	123.73

Years 3–5 same as year 2
Net present value at 20% discount rate = $-262.27
Net benefit per year after year 1 = $-123.73
Annualised net benefit, treating establishment costs as depreciation = $121.87
Note: Base farm model is same as in Table A2.

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