The adoption and scaling up of the use of fodder shrubs in central Kenya

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Abstract

Fodder shrubs have great potential for increasing the income of smallholder dairy farmers. This paper documents their use 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 planting and use of fodder shrubs requires much more than the transfer of seed and knowledge; it involves building partnerships with a range of stakeholders, ensuring the appropriateness of the practice and farmers' interest in it, assisting local communities to mobilise resources, and ensuring the effective participation of farmer groups in testing, disseminating, monitoring and evaluating the practice.

Introduction

Low quality and quantity of feed resources are the greatest constraints 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. In these peri-urban areas, small farm sizes exacerbate 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; moreover, unlike grass species, the shrub leaves maintain their levels of protein even during the dry season. In addition, farmers can use the shrubs for many other purposes, such as for hedges along boundaries and around the homestead, for prevention of soil erosion along contours and for fuelwood.

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Since the early 1990s, the National Agroforestry Research Project (NAFRP), based at the Kenya Agricultural Research Institute (KARI), Regional Research Centre, 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 (KEFRI), and the World Agroforestry Centre. By 1997, about 1000 farmers on surrounding on-farm trial sites had planted calliandra. Nevertheless, the project lacked the staff and resources required to extend the planting to other areas of the Kenyan highlands. A second project, financed by the System-wide Livestock Programme (SLP) of the Consultative Group on International Agricultural Research (CGIAR), helped facilitate the scaling up of fodder shrub adoption throughout the central Kenya highlands. "Scaling up" is defined as "bringing more quality benefits to more people over a wider geographical area, more quickly, more equitably, and more lastingly (IIRR 2000)." The project ran from 1999 to 2001 and involved the World Agroforestry Centre, KARI and the International Livestock Research Institute (ILRI).

This paper describes the development of fodder shrub technologies by researchers and farmers, and the process of scaling up the benefits of fodder shrubs to farmers throughout central Kenya. It 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.

Study area description

The coffee-based land-use system of central Kenya, ranging in altitude from 1300 to 1800 m, is located on the slopes of Mount Kenya. Rainfall occurs in 2 seasons, March–June and October–December, and averages 1200–1500 mm annually. Soils, primarily Nitosols, are deep and of moderate–high fertility. Population density is high, ranging from 450–700 persons/km^2. In the Embu area, farm size averages 1–2 hectares. Most farmers have title to their land; thus, their tenure is relatively secure. The major crops are coffee (as a cash crop), and maize and beans (produced for food). Most farmers also grow napier grass *(Pennisetum purpureum)* for feeding to their dairy cows. Farmers tend to crop their fields continuously because of the shortage of land. About 80% of farmers have improved dairy cows. On average, there are 1.7 cows/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. About 40% of the farmers also have goats, averaging 3.2 goats/family (Minae and Nyamai 1988; Murithi 1998). Dairy goats are a rapidly growing enterprise and are particularly suitable as livestock for poorer households.

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. About 45% of farmers buy commercial dairy meal (nominally 16% crude protein) to supplement their cows' diets (Murithi 1998). Farmers complain that the price ratio between dairy meal and milk is not favourable, that they lack cash for buying dairy meal, that the nutritive value of dairy meal is suspect and highly variable, and that it is difficult for them to transport dairy meal from the market to the homestead (Franzel *et al.* 1999)

Research on fodder shrubs

In Kenya, the initial research on fodder shrubs began in the 1980s; ILRI and KARI conducted this research. In the Embu area, NAFRP scientists initiated the first on-farm trials in 1991, testing 3 promising species (calliandra, *Sesbania sesban* and *Leucaena leucocephala*) to find out which niches farmers preferred for planting the shrubs. Because of the limited size of farms, farmers and researchers focused on integrating the shrubs into existing cropping systems rather than planting the trees in pure-stand fodder banks. In farmer-designed, farmer-managed trials, farmers planted the shrubs as they wished in niches of their choosing, including:

- As hedges around the farm compound. Hedges are a common feature of homesteads in central Kenya and were traditionally planted using relatively unproductive, non-browse species, to prevent free-ranging livestock from eliminating them. However, livestock are now confined and there is great potential for replacing unproductive hedges with fodder hedges (Thijssen *et al.* 1993).
- Along contour bunds and terrace edges on sloping land. They thus help to conserve soil and, if pruned continuously, have little effect on neighbouring crops.
- Intercropped with napier grass. Results from intercropping experiments suggest that introducing calliandra into napier grass has little effect on napier grass yields (Paterson *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 (NAFRP 1993).

Pruning management has also been examined. The first pruning for fodder is carried out 9–12 months after planting; thereafter, pruning is carried out 4 or 5 times/year (Roothaert *et al.* 1998). Leafy biomass yields/year increase as pruning frequency decreases and cutting height increases; however, adjacent crop yields are negatively affected (ICRAF 1992). The most productive compromise is probably in the range of 4–6 prunings/year at a cutting height of 0.6–1 m, which gives an approximate yield of 1.5 kg DM/tree/year planted at 2 trees/m in hedges under farmers' conditions. Thus, a farmer would need about 500 trees to feed a cow throughout the year at a feeding rate of 2 kg/d DM, providing about 0.6 kg crude protein. A typical 1.5-ha farm would have about 500 m of perimeter and several hundred metres in each of 3 other niches: along terrace edges or bunds, along internal field and homestead boundaries, and in napier grass plots. Only 250 m of hedges would be needed to accommodate 500 trees, in order to feed a dairy cow (Paterson *et al.* 1998).

On-farm feeding trials have confirmed the effectiveness of calliandra, both as a supplement to the basal diet and as a substitute for dairy meal. One kilogram of dry calliandra (24% crude protein and digestibility of 60% when fed fresh) contains about the same amount of digestible protein as 1 kg of dairy meal (16% crude protein and 80% digestibility) (Paterson *et al.* 1998); each increases milk production by about 0.75 kg (*e.g.* from about 10.0 kg/d to 10.75 kg/d) under farm conditions. However, the response is variable as it depends on factors such as the health of the cow and the quantity and quality of the basal feed (Paterson *et al.* 1998). Furthermore, the effects of calliandra and dairy meal have been found to be additive, suggesting that the 2 feeds are nutritionally interchangeable (Paterson *et al.* 1998). 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.* 1999).

Calliandra seedlings are raised in nurseries and transplanted following the onset of the rains. Experiments on seedling production have confirmed that plants may be grown in raised seedbeds rather than by the more expensive, laborious method of planting in polythene bags (O'Neil *et al.* 1997). Researchers are also conducting studies on other shrub species, both exotic and indigenous, to help farmers diversify their feed sources. These species include *Leucaena trichandra*, *Morus alba* (mulberry) and *Sapium ellipticum*. In the late 1990s, 2 of these species were introduced to farmers: *Leucaena trichandra*, an exotic, and *Morus alba*, a naturalised species (*i.e.*, introduced over 100 years ago). Research continues on indigenous species but none has yet been identified that can be pruned intensively. *Desmodium intortum*, an 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.

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). The first survey took place in 1995 and involved 45 randomly selected farmers from a group 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 somewhat higher incomes than the average for farmers in the area and their farm size was about 20% larger.

Assessing adoption amongst farmers who participated in on-farm trials and special projects is sometimes questionable, as extensive contact and incentives may bias the farmers in favour of the technology being assessed. In this particular case, we consider 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 survey findings showed that lack of information about calliandra was an important problem. For example, one farmer somehow was unaware 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 about 84 trees survived. The high survival rate (93%; s.d. = 13%) was consistent with data collected in farmer-managed trials in the same area, which included some of the same farmers (NAFRP 1993). About 80% of the farmers used potted seedlings to establish their first calliandra plantings, 16% established their own nursery and 4% direct seeded. First plantings occurred between 1988 and 1993 with most taking place in 1992 (see Figure 1). At the time of the first survey, most of the farmers had less than 3 years of experience in planting calliandra.

Over 80% of the farmers expanded their calliandra plantings after their first planting (see Table 1). About 36% expanded their plantings twice and 18% expanded their plantings 3 or 4 times. As farmers expanded their plantings, the number of trees planted[1] per expansion tended to increase, although, because of the high variability in numbers, the differences were not statistically

[1] Number of trees surviving is used instead of number of trees planted; in many cases the farmers could not remember how many trees they had planted whereas surviving trees could be counted.

significant (see Table 1). In farmers' fourth and fifth plantings, the average number of trees planted was 54% higher than in their first plantings.

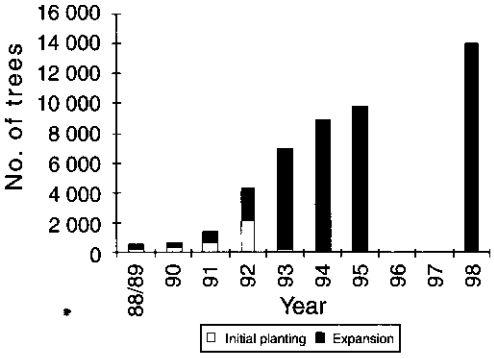

Figure 1. Numbers of *Calliandra* trees planted by 45 surveyed farmers who started planting 1992/93 or earlier.

Table 1. Farmers' expansion of calliandra plantings and numbers of trees per planting.

Planting	No. of farmers (percentage)	Average no. of 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), a 1.6-fold increase. Six of the farmers had over 300 trees. The rate of increase slowed somewhat over the next 3 years; by 1998, farmers had an average of 311 trees (Ondieki 1999). The total number of trees planted by sample farmers increased from about 4000 trees in 1992 to more than 14 000 in 1998 (see Figure 1).

There were important differences in the method of planting and source of planting material between farmers' successive plantings (see Table 2). Whereas the principal method in farmers' 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. Accordingly, farmers' own trees and other sources (*e.g.* friends and relatives) replaced projects as the principal source of planting material from the third planting onwards. Of the 65 incidents of expansion, 33 involved the planting of seed or seedlings obtained from projects and 32 involved seed or seedlings obtained from a farmer's own farm or from another person. By mid-1995, 36% of the farmers had established calliandra nurseries; about 75% of these used seed from their own trees.

Table 2. Planting method and source of planting material for successive plantings of calliandra, 1995.

	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

The niches where farmers planted calliandra were sometimes determined by farmers and sometimes jointly by researchers and farmers; for example, when an on-farm trial concerned a particular planting niche. Overall, the most common niches were in lines on contours (62% of farms), intercropped with food crops or coffee (40%) and on homestead boundaries (35%) (Table 3). In plantings where farmers chose the niches, the most common choices were: homestead boundaries, external boundaries and in lines on contours. Only 2 farmers planted calliandra in pure-stand fodder banks, reflecting farmers' reluctance to allocate even small plots to calliandra.

Table 3. Niches where farmers planted calliandra, 1995.

Niche	No. of sample farmers (percentage)	
	All plantings[1]	Plantings where farmer chose niche (total 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)

[1] Percentages do not add up to 100 because farmers often planted in more than one niche.

In some of the on-farm trials, farmers were asked to plant in a particular niche.

Associations between uptake of calliandra and selected farm and household characteristics were not obvious; however, 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 farmer age; 6 of the 7 farmers under 30 years of age adopted compared with only 9 of 15 who were over 55 years of age. The dairy enterprise's rank in importance among other enterprises was significantly associated with adoption at the $P<0.10$ level (Chi-squared 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 calliandra periodically to a height of 0.5–1.0 m after it had reached a height of about 1.0–1.4 m (*i.e.*, before it became too difficult to reach or produced too much shade on neighbouring crops). About 80% of farmers used pruning shears, which they owned already for use on their coffee and tea plants. Around 13% used a machete, claiming that the stem was too thick to cut with shears. A further 9% broke off branches by hand, primarily in order to save time. 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 range of types of animals. Most farmers (91%) fed it to dairy cows, while 42% and 47% of farmers, respectively, fed it to heifers and goats. Between 5% and 20% fed calliandra to the following animals: bulls, sheep, rabbits, calves and poultry. Many farmers (69%) fed calliandra to dry cows as well as lactating cows. This was often because a dry cow and a lactating cow fed from the same trough and it was not practical 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% of farmers mixed calliandra with napier grass when feeding; about 44% also fed calliandra separately at times. As with dairy meal, calliandra was often fed during milking to help to keep the cow contented.

Only 1 farmer claimed that he fed calliandra to his cows throughout the year. On average, farmers fed their cows on calliandra about one-third of the time; this was because the quantities they had were insufficient and growth slows during the dry season. Only 12% reduced cutting during the wet season in order to have increased supplies during the dry season; farmers were sceptical about this strategy, because they felt that not cutting calliandra would increase its competition with crops. About 75% of the farmers fed material to their animals within an hour after cutting, in line with the recommendation to feed only fresh leaves (Roothaert *et al.* 1998). This recommendation has since been changed, as there is little difference in nutritional quality between fresh and dry leaves (Tuwei *et al.* in press).

About 84% of farmers fed dairy meal to their cows, although many said that, because of cash shortages, they did not feed continuously. Most (62%) used calliandra as a supplement to dairy meal, *i.e.*, they did not reduce their use of dairy meal when they fed calliandra. In contrast, 27% used calliandra as a complete substitute for dairy meal and 10% as a partial substitute. About 88% of farmers claimed that calliandra increased their milk production and 89% claimed that their cows found it highly palatable.

Some farmers claimed that they obtained benefits from calliandra in addition to increases in milk production. In response to an open question, 24% said that fuelwood production was a benefit and 13% cited soil conservation; moreover, 7% each cited increases in milk creaminess, calliandra's beautiful appearance and money saved by not having to buy dairy meal. The only negative aspects cited were scales, a minor pest that slightly reduces productivity (cited by 18% of farmers), and reduction of yield of adjacent crops (7%) by calliandra.

The farmers varied considerably in the way they used the seed produced by their calliandra trees. Around 40% of farmers harvested seed; the major reasons given by farmers who did not harvest seed were lack of interest and lack of knowledge about propagation techniques. About 33% of the farmers gave seed to others; each gave to an average of 13 other farmers (this number is skewed upwards because 2 farmers between them gave seed to 110 farmers — the median number

of persons given seed was 4). Two farmers sold seed or seedlings to other farmers. Furthermore, about 66% of the farmers had left some trees to seed at the time they were interviewed, indicating their strong interest in expanding calliandra production or in distributing seed.

Each person who harvested seed, did so from an average of only 8 trees. It is advisable to harvest from at least 30 trees in order to conserve the genetic diversity of the germplasm. If the genetic base in an area is too narrow, inbreeding causes a significant decline in productivity (Roothaert *et al.* 1998). Farmers were unaware of the need to harvest from at least 30 trees. Moreover, some may be reluctant to leave so many trees for seed because they become tall and reduce the growth of adjacent crops.

About 91% of the farmers indicated an interest in increasing their calliandra plantings. Surprisingly, most of the farmers (58%) had never visited another farmer who had planted calliandra. Only 19% had visited other calliandra farmers as part of extension tours and 34% had visited other calliandra farmers on their own.

Scaling up fodder shrub use: achievements and impact

The NAFRP helped farmer groups in the Embu area to set up 14 calliandra nurseries in 1997, 26 in 1998 and 12 in 1999. However, extension work was outside the project's mandate. Therefore, a new project financed by SLP recruited a dissemination facilitator 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. Equally important and more time-consuming, the scaling up aimed to build partnerships with a range of stakeholders in new areas; to assess whether feed shortage was a problem identified by farmers, to gauge their interest in planting fodder shrubs and to determine whether the shrubs were appropriate in their environment; to assist farmer groups and communities to effectively mobilise local and external resources for establishing calliandra nurseries; and to ensure the effective participation of farmer groups and stakeholders in testing, disseminating, monitoring and evaluating the practice. These tasks were considered vital to ensure 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 7 districts (each district comprises approximately 2000–4000 km^2 and 200 000–500 000 people) were identified; organisations included government departments, non-governmental organisations (NGOs), churches and community-based organisations. Fortunately, most were already using participatory research and development methods. Moreover, the organisations confirmed that farmers with whom they worked 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 the 7 districts but were focused in clusters within each district to reduce costs and to facilitate monitoring and the exchange of information amongst groups. Meetings were held with farmers to discuss the problems they had in feeding their cows and to explain to them the costs, benefits and risks of planting fodder shrubs. Farmer visits were arranged to see farmers in the Embu area who already had several years of experience in growing calliandra and feeding it to their dairy cows and goats. Most of the farmer groups paid for their own transportation and subsistence costs on these visits. Seeing and discussing calliandra with experienced farmers was an effective means of promoting calliandra planting and of providing 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 2–3 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.

In 1999–2000, the project assisted staff of the following types of organisations to help farmers establish nurseries: the provincial administration in 2 provinces, 3 departments of the Ministry of Agriculture and Rural Development, 1 international NGO, 4 local NGOs, 1 extension service of a private company, 2 church extension services, 10 community-based organisations and 150 farmer groups. Farmer groups ranged in size from 4 to 50 members and averaged about 17 members. Most of the groups were already in existence before the project, promoting activities such as dairy goats, handicrafts, domestic water tanks, soil conservation, organic farming and shrub nurseries. Most (76%) of the groups included both men and women; however, 15% were women's groups and 9% were men's groups (see Table 4). Women accounted for 60% of all group members. Most groups had more than 1 nursery. Nurseries were located on the farm of a member who had access to water during the dry season, an essential criterion for successful nurseries. Group members divided the labour amongst them and shared the seedlings produced. Ten nurseries were also established in school or church compounds and served as demonstration sites for farmers in the area.

Table 4. Types of farmers and groups establishing fodder shrub nurseries, central highlands of Kenya, 2000.

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

Table 5. Expansion in numbers of farmer groups planting fodder shrub nurseries in the central highlands of Kenya.

Season and year	No. of districts	No. of farmer 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

By the end of 2000, the 150 groups involving over 2600 farmers had developed 250 nurseries (see Table 5). On average, farmers each transplanted about 400 calliandra seedlings, of which about 240 (60%) survived. Drought was the main cause of the high seedling mortality. Rainfall was less than normal during 3 consecutive seasons, namely: the short rains of 1999, and long and short rains of 2000.

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

The project also started disseminating other fodder shrub species; by 2001, farmers in 80 groups had planted *L. trichandra*, 70 groups had planted *M. alba* and 13 groups planted an herbaceous legume, *Desmodium intortum*. Farmers value diversification because it reduces the risk of pest and disease attacks, and improves feed quality. By 2002, farmers had an average of 352 fodder trees.

Monitoring, farmer innovations and problems

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

Severe drought and poor distribution of rainfall increased the mortality of seedlings in the nurseries and shrubs in the field. Unlike many areas of Africa, in central Kenya, severe drought during the long rains season is rare. Nevertheless, because of the high demand for seed from nurseries, farmers are being urged to locate nurseries near permanent sources of water. Infestation by crickets, hoppers and aphids has also led to a significant loss of seedlings. These pests are particularly damaging during dry periods. A high turnover of staff, poor morale and a lack of resources (such as transportation) at the Ministry of Agriculture have also limited success. The SLP project occasionally assists ministry staff

with transportation and subsistence allowances, which greatly increases 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.

Assessing economic impact and potential demand

Partial budgets were drawn up to show the effects on farmers' net incomes of using fodder shrubs under 2 scenarios: (1) using calliandra as a supplement to the normal diet; and (2) as a substitute for purchased dairy meal. The base analysis assumed a 1.5 ha farm with 500 trees and 1 zero-grazed dairy cow and covered a 5-year period. It was assumed that trees were planted on external boundaries. Benefits included in the analysis were: the effect of calliandra on milk production (in the supplementation case); the cash saved by not purchasing dairy meal; and the interest on cash freed up (in the substitution case). Costs were those of the seedlings and labour for planting, cutting and feeding calliandra. Average prices over a 3-year period, 1996–98, were used for dairy meal, milk and labour. Returns are expressed in 1998 US dollars, adjusted for inflation. Coefficients, prices and sources of data used in the economic analysis are shown in Table 6.

Partial budgets for calliandra as a supplement to farmers' basal feed and as a substitute for dairy meal are shown in Tables 7 and 8, respectively. Tree establishment costs (including the costs of seedlings and planting) are modest, US$6.58/500 trees[2]. Beginning in the second year, harvesting and feeding 2 kg dry calliandra/d as a supplement throughout the lactation period

[2]US$1 = 57 Kenya shillings on average for the period 1996–98.

Table 6. Coefficients and prices used in the economic analysis.

Item	Value	Data source
Coefficients		
Period of analysis (yr)	5	Assumption
Lactation period (d)	300	Assumption
Time fed calliandra (d)	365	Assumption
Time fed dairy meal (d)	365	Assumption
Calliandra fed (kg/cow/d)	6 (fresh) = 2 (dry)	Assumption
Dairy meal fed (kg/cow/d)	2	Assumption
Milk output (kg/d/kg dry calliandra)	0.75	Paterson *et al.* 1996
Milk output (kg/d/kg dairy meal)	0.75	Paterson *et al.* 1996
Calliandra leaf yield — Year 1 (kg/tree)	0	Farmers' experience
Calliandra leaf yield — Years 2–5 (kgDM/tree/yr)	1.5	Paterson *et al.* 1996
Trees required to feed one cow for a year	487	Computed from above
Tree survival rate (%)	80	Survey data
Calliandra planting labour (trees/h)	20	Farmers
Calliandra cutting and feeding labour (min/d)	15	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 (US$/kg)	0.201	Market survey, 1996–98
Transport of dairy meal (US$/kg)	0.008	Market survey, 1996–98
Seedling cost (bare-rooted) (US$/100 seedlings)	0.526	Swinkels (unpubl. data from on-farm trial)
Labour cost (US$/h)	0.118	Farmers, 1996–98
Milk price (farm gate) (US$/kg)	0.296	Farmers, 1996–98
Annualised value of fixed cost for seedling establishment for 500 trees (US$)	2.18	Use of capital recovery formula[1] (Spencer *et al.* 1979)
1 US$ = 57 Kenya shillings		Average exchange rate, 1996–98

[1]$K = (rv)/(1 - (1 = r)^{-n})$ 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 calculated.

increases milk production by about 450 kg/yr, an increase of about 10% over base milk yields. Incremental benefits/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$258.39. Net benefits/cow per year after Year 1 are US$122.32.

Table 7. Partial budget: extra costs and benefits of using calliandra as a supplement for increasing milk production (US$/yr, 1996–98).

	Extra cost		Extra benefits		Net benefit
Year	Item	US$	Item	US$	US$
1	Tree seedlings (n = 500)	3.05		0	
	Planting labour	3.53			
	Subtotal =	6.58			–6.58
2	Cutting/feeding labour	10.75	450 kg extra milk	133.07	122.32
3–5		Same as Year 2			

Net present value at 20% discount rate = US$258.39/yr
Net benefit/yr after Year 1 = US$122.32

Annualised net benefit treating establishment costs as depreciation = US$120.14

Base farm model: the farm has 500 calliandra trees and one dairy cow. The cow consumes a basal diet of 80 kg napier grass/d and produces 10 kg milk/d. Two-thirds of the trees are planted on homestead and external boundaries; one-third are planted on contours with napier grass. They are planted at a spacing of 50 cm.

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 during the year in buying and transporting 730 kg dairy meal. Incremental benefits/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 US$300.15. The net benefits/cow/year after Year 1 are US$141.68.

Therefore, using calliandra increases farmers' income by about US$122–142/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 increases a farmer's income by about US$204–241/year (Murithi 1998), representing an increase of about 10% in total household income.

The partial budget was recalculated using 2001 prices; these were somewhat lower than in 1996–98, reflecting the devaluation of the Kenyan currency. Increases in farmers' income/cow per year after the first year were US$98 when calliandra was used as a supplement and US$124 when used as a substitute.

The costs of establishing, maintaining and feeding calliandra are low. In both the substitute and supplement scenarios, farmers recover their costs very quickly (*i.e.*, 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/kg (dry) 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. To some farmers, calliandra provides benefits such as firewood, erosion control, a boundary marker, a fence or decoration. It also increases the butterfat content of milk, giving it a richer taste and creamier texture. When used as a feed supplement, calliandra may improve animal health and fertility and reduce the inter-calving interval. Finally, several farmers noted that calliandra had important benefits relative to dairy meal, namely: 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 notion that farmers prefer enterprises and practices that do not rely on uncertain governmental or market mechanisms (Haugerud 1984).

The major costs that were omitted from the analysis are the opportunity cost of the land occupied by the trees and the effect in reducing yields of adjacent crops. However, these costs are likely to be relatively low, especially when calliandra replaces or is added to an existing hedge or bund, is pruned frequently, or is used as a hedge border on homesteads, roads, paths or external boundaries.

Sensitivity analysis was conducted to determine how changes in key parameters would affect the results (Table 9). A 30% reduction in 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 increases the

Table 8. Partial budget: Extra costs and benefits of using calliandra as a substitute for dairy meal in milk production (US$/yr, 1996–98).

Extra cost			Extra benefits		Net benefit
Year	Item	US$	Item	US$	US$
1	Tree seedlings (n = 500)	3.05		0	
	Planting labour	3.53			
	Subtotal	6.58			–6.58
2	Cutting/feeding labour	10.75	Saved dairy meal cost	147.10	
			Saved dairy meal transport	5.32	
			Interest on capital freed up	0.90	
			Subtotal	152.43	141.68
3–5			Same as Year 2		

Net present value at 20% discount rate = US$300.15
Net benefit/year after Year 1 = US$141.68
Annualised net benefit treating establishment costs as depreciation = US$139.48

Base farm model: the farm has 500 calliandra trees and one dairy cow. The cow consumes a basal diet of 80 kg napier grass/d and produces 10 kg milk/d. Two-thirds of the trees are planted on homestead and external boundaries; one-third are planted on contours with napier grass. They are planted at a spacing of 50 cm.

Table 9. Sensitivity analysis showing the effect of changes in key parameters on the profitability of using calliandra (US$/yr, 1996–98).

	Calliandra as supplement		Calliandra as substitute	
	Net present value	Annualised net benefit	Net present value	Annualised net benefit
Base analysis	258	120	300	139
Milk price +30%	344	158	300	139
Milk price –30%	172	78	300	139
Dairy meal price +30%	258	118	395	184
Dairy meal price –30%	258	118	205	95
Discount rate 30%	199	118	231	140
Labour cost +30%	250	114	292	136
One kg dairy meal or one kg dry calliandra gives one kg milk	354	162	300	139
One kg dairy meal or one kg dry calliandra gives 0.5 kg milk	163	73	300	139

NPV by 32%. A reduction in price of 30% decreases the NPV by 32%. A higher discount rate, *e.g.* 30% instead of 20%, would decrease the NPVs of calliandra in both scenarios by 23%. A 30% increase in labour costs, however, would have little effect, decreasing NPVs by less than 5%. If one assumes that 1 kilogram of dairy meal or 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 fairly stable. Despite the range of negative situations tested, net present values and net benefits remained positive.

Fodder trees seem to be appropriate for smallholder dairy farmers throughout the highlands of eastern Africa. Calliandra, for example, can grow at altitudes between 0 and 2200 m, requires only 1000 mm rainfall/year, can withstand dry seasons up to 4 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. Therefore, the potential impact of fodder trees seems to be very large. If 50% of Kenya's estimated 625 000 smallholder farmers who own dairy cows, planted 500 fodder shrubs each, the net benefits/year would reach US$81M (Franzel *et al.* 1999).

Fodder trees also have important potential in the large-scale dairy sector, which supplies 30% of Kenya's milk. Moreover, farmers at numerous other sites in east and southern Africa (including Ethiopia, Uganda, Rwanda, Tanzania, Zimbabwe, Malawi and Zambia) are presently planting fodder trees. Results are promising.

Factors contributing to success and challenges

Several factors have contributed to the achievements to date:

- Farmers' demand for fodder shrubs has been high, mainly because the shrubs save cash and require only small amounts of land and labour.
- The project area is noted for the dynamism of its farmers and access to markets is fairly high, 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 work 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 farmer groups, instead of individual farmers, economises on scarce training skills and transportation. In addition, working with groups ensures greater farmer-to-farmer dissemination and exchange of information.
- The strong partnership between researchers, extension workers and farmers in the project facilitates the flow of information amongst 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 the Department for International Development, United Kingdom, to scale up the impact of fodder shrubs in 4 countries of east Africa: Kenya, Uganda, Rwanda and Tanzania.
- Commercial seed production and distribution are slowly emerging in project areas; however, it is not clear if seed production will continue to grow and meet local demand. Greater emphasis is needed on promoting community-based seed production and distribution through a range of partners: farmer 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. KARI-Embu has the lead role in Kenya for evaluating fodder trees and is increasing its emphasis on indigenous species.

Finally, experience confirms that successful scaling up of a new practice requires much more than transferring seed and knowledge about the practice. Rather, facilitators need to: build partnerships with and amongst a range of stakeholders; ensure farmers maintain interest in the practice and its appropriateness to their conditions; assist farmer groups and communities to effectively mobilise local and external resources; and ensure the effective participation of farmer groups and stakeholders in the processes of testing, dissemination, monitoring and evaluation. A critical question is when, and under what circumstances, the spread of the practice, that is, of information and germplasm, will become self-sustaining.

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