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Fodder Dissemination for Soil Conservation and Cash Generation in the Central Kenyan Highlands

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ABSTRACT

High population densities characterize the central Kenyan highlands. Exploitation by small-scale, resource poor farmers, of decreasingly productive lands has led to increased soil erosion. Successful on-station and on-farm trials carried out by the National Agroforestry Research Project (NAFRP) identified *Calliandra calothyrsus*, a leguminous fodder tree, as a species that could be grown on-farm, used as a barrier species in contour hedges, and substitute for purchased dairy meal to improve the basal fodder diet of Napier grass (*Pennisetum purpureum*). On-farm research demonstrated that contact farmers were enthusiastic about using calliandra as a dairy meal substitute. In January 1997, NAFRP began to facilitate the dissemination of calliandra and popularize its use by small-scale dairy farmers. Niches preferred by farmers (50%) were on soil conservation structures and along the contour of sloping fields. During the two rainy seasons of 1997, nearly 88,500 seedlings from these community-based group nurseries were transplanted into fields of more than 385 farmers. Based on the need for 500 seedlings for a cow per year, enough seedlings were transplanted to support more than 177 cows. At a net benefit of US$ 150 a cow per year; this represents a contribution of US$ 26,550 a year into the community. Through project support, additional group nurseries are developing their own capacities for calliandra production. Preferred niches continue to be along contours thereby maintaining environmental quality and contributing to the sustainable stewardship of their natural resource base.

INTRODUCTION

The highlands of central Kenya are characterized by a rolling to steep topography with a medium to high soil erosion potential (Kassam et al., 1992). Although highland soils are generally of medium inherent fertility, they are seriously prone to water erosion because of high rainfall and sloping topography (Jaetzold and Schmidt, 1983). High population pressure (500 to 800 persons km^{-2}) has led to the sub-division of family farms into very small units (~1.5 ha) that require intensive agricultural practices to produce sufficient food for home consumption and outside sales (Minae and Nyamai, 1988; Murithi, 1998). This has led to the exploitation of decreasingly productive lands and increasing soil erosion.

Coffee is the principal cash crop, occupying roughly one-third of the farm area, and most farmers practice dairy under cut and carry systems. The main feed source for dairy cows is Napier grass (*Pennisetum purpureum*), supplemented during the dry season by crop residues, such as maize (*Zea mays*) and bean (*Phaseolus vulgaris*) stover, banana (*Musa sapientum*) leaves and pseudostems, and indigenous fodder trees (Abate et al., 1992; ICRAF, 1997). Acute fodder shortages, particularly during the dry seasons, have been noted as critical constraints affecting farmers throughout the bimodal highlands of Kenya.

Background research

The National Agroforestry Research Project (NAFRP) based in Embu, Kenya was established in 1991 with the priority mandate for the acquisition, evaluation, adaptation, dissemination, and adoption of fodder tree species that could address the needs of small-scale dairy farmers in the central highlands. Successful on-station and on-farm trials identified *Calliandra calothyrsus*, a leguminous fodder tree, as a species that could be grown on-farm and used as a supplement or substitute for purchased dairy meal to improve the basal fodder diet of Napier grass (*Pennisetum purpureum*). Contact farmers were enthusiastic about calliandra and expressed an interest in using it as a dairy meal substitute.

On-farm feeding trials confirmed the effectiveness of calliandra as both a supplement to the basal diet and as a substitute for dairy meal (Paterson et al., 1996). One kg of dry calliandra has the same amount of digestible protein as 1 kg dairy meal. On a fresh weight basis, 3 kg of calliandra is equivalent to 1 kg of dairy meal and the effects of calliandra and dairy meal were found to be additive, suggesting that the two feeds are nutritionally interchangeable. Because of limited farm-size in the central Kenya highlands, researchers and indeed farmers have focused on integrating calliandra into the existing cropping system rather than planting it in pure-stand fodder banks (Minae and Nyamai, 1988; Murithi, 1998). Project research indicated that a farmer would need about 500 trees to feed a cow throughout the year at a rate of

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2 kg d^{-1} dry matter (6 kg fresh material). A typical farm of 1.5 ha would have sufficient perimeter and internal niches to accommodate twice that number of calliandra trees (Paterson et al., 1996).

Over a 10-season study period, the combination of Napier grass and calliandra in a contour hedge oriented perpendicular to the slope in a maize field was demonstrated to provide a sustainable agroforestry technology for soil and water conservation and the production of high-quality fodder (O'Neill et al., 2001). After the initial 2 hedge-establishment seasons, hedges were effective in reducing runoff and soil loss. In addition to maize production, hedges produced more fodder than required for a lactating cow in 7 of the 8 fodder-producing seasons.

Despite strong interest, a literature review did not reveal a single case of widespread adoption and dissemination of introduced, managed fodder trees by small-scale farmers in Africa. A study was carried out in 1995 to examine the early stages of calliandra adoption among smallholder dairy producers testing calliandra in the highlands of central Kenya (Franzel et al., 1999). This study was conducted in the portion of Embu District that falls within the coffee-based system. A random sample of 45 farmers from an initial group of 83 farmers, who had experimented with calliandra collaboratively with either the National Dairy Development Project (NDDP) or NAFRP, was interviewed during a formal survey in mid-to-late 1995.

Farmers ranked dairy as their second most important cash enterprise; 81% of the farmers had improved dairy cows, 1.7 cows per family, raised in cut and carry systems (Franzel et al., 1999). The demand for milk is high; some is sold privately and some to the Kenya Cooperative Creameries, and a large portion is reserved for home consumption. Forty-five percent of the farmers buy commercial dairy meal (nominally 16% crude protein) to supplement the basal diet. Whereas the extension service recommends 4 kg d^{-1} dairy meal, farmers' feeding rates were considerably lower. Farmers complained that the price ratio between milk and dairy meal was not favorable, that they lacked cash for buying dairy meal, that its nutritive value was suspect and highly variable, and that it is difficult for them to transport dairy meal from markets to their homesteads (Franzel et al., 1999).

Economic analysis examined partial budgets to show calliandra-use effects on net income under two scenarios: (1) using calliandra as a supplement to the normal diet and (2) as a substitute for purchased dairy meal (Franzel et al., 1999). The base analysis assumed a five-year period with a 1.5-ha farm, 500 trees, and one dairy cow in a cut-and-carry management system. Budgets for calliandra as a supplement to farmers' basal feed and as a substitute for dairy meal were calculated in 1997 prices of 1 US Dollar equal to 53 Kenya Shillings. In the first year, farmers' investments of planting labor and seedlings amounted to US$ 7.00. Beginning in the second year after transplanting, harvesting and feeding 2 kg d^{-1}dry calliandra as a supplement throughout the lactation period increased milk production by about 450 kg yr^{-1}, an increase of 10% over base milk yields. Net benefits per cow per year after the initial year were US$ 135. By feeding calliandra as a substitute, the farmer saved money he would have spent buying and transporting 730 kg dairy meal during the year. In the budget assessing calliandra as a substitute for dairy meal, incremental benefits per year after the first year were over 11 times higher than incremental costs. The net benefits per cow per year during year 2 - 5 were US$ 163. Expressed in laymen's terms, using calliandra increased farmers' annual income by about US$ 150 per cow per year (Franzel et al., 1999).

Following these encouraging trials, NAFRP embarked on a dissemination program to popularize the use of calliandra by small-scale dairy farmers in the central Kenyan highlands. As farmers became aware of the potential of calliandra as a superior fodder species, the project was not able to meet farmers' seedling demands through its own tree nursery.

MATERIALS AND METHODS

A preliminary study was initiated with farmers to determine a feasible and affordable method of propagating calliandra (O'Neill et al., 1997). The study involved a comparison of three different methods of calliandra propagation: 1) potted seedlings (in polythene bags) with cattle manure; 2) open rooted seedlings in 'Swaziland' beds with cattle manure; 3) open rooted seedlings in 'Swaziland' beds without cattle manure; and; 4) planting seeds directly into fields. The experiment was carried out at four sites in existing community nurseries from December 1995 to July 1996.

Upon completion of the preliminary propagation study, a dissemination project was initiated in January 1997 to promote calliandra use for soil conservation and fodder production in three divisions of Embu District. To strengthen the links between researchers, extension staff, and farmers, twelve farmer groups were selected in collaboration with extension personnel from the Ministry of Agriculture, Livestock Development and Marketing and the Ministry of Environment and Natural Resources. Each group received 1 kg of calliandra seed. All participating groups were instructed in basic nursery management and sowed their seeds in nurseries during February 1997; field transplanting was carried during the first rainy season in April. Farmers selected niches for seedling transplants that would accommodate their needs and desires. Niches selected by farmers were documented so appropriate recommendations could be made. During the second rainy season of 1997, project and extension staff continued their dissemination work in Embu District and initiated group nurseries in two immediately neighboring districts.

RESULTS AND DISCUSSION

Results of this preliminary study (Table 1) demonstrated that potted seedlings had generally higher mean survival percentage than open rooted seedlings in all sites. The differences in mean survival percentage between potted and open-rooted seedlings with manure applications was small, implying that both methods can be used to propagate calliandra. Direct sowing of calliandra seeds was a failure on most farms. The cost of polythene tubes gives the Swaziland

Table 1. Mean field survival of calliandra (*Calliandra calothyrsus*) seedling during the 1996 long rainy season in four catchments of Embu District, Kenya.

Method of propagation	Mean survival percentage (%) (N = 38)			
	Ndunduri (LH1)†	Karangi (UM1)	Njoga (UM2)	Kyethiga (UM3)
Polythene bags (potted) with manure	93 a	94 a	91 a	88 a
Swaziland beds with manure	73 b	82 b	85 a	83 a
Swaziland beds without manure	68 b	69 c	n/a‡	67 b
Direct sowing	24 c	6 d	12 b	0 c

†AEZ = Agroecological Zone: LH1 = Lower Highlands 1; UM 1 = Upper Midlands 1 (Tea-Coffee Transition Zone); UM 2 = Upper Midlands 2 (Coffee Zone); UM 3 = Upper Midlands 3 (Marginal Coffee Zone) (Jaetzold and Schmidt, 1983).
‡n/a - Not applicable in Kyethiga, no seedlings planted without manure.
Values followed by the same letter are not significantly different at the 5% significance level according to the Duncan multiple range test.

Table 2. Number of calliandra (*Calliandra calothyrsus*) seedlings planted plus additional seedling requirements during the 1997 long rainy season in 12 group nurseries of Embu District, Kenya.

Nursery	AEZ†	Farm Size (ha)	Cows	Seedlings Planted	Seedlings Required
Jisaidie	UM 2	1.6	1.9	3,475	6,450
Kamiugi	UM 2	1.2	1.4	6,480	4,920
Karangi	UM 1	1.2	1.5	2,100	14,400
Kariari	LH 1	1.4	2.0	3,450	8,500
Kathangari	UM 2	1.2	1.9	3,100	8,150
Kianjuki	UM 2	1.7	1.6	3,765	8,590
Kirurumwe	UM 3	1.6	1.9	6,500	9,700
Kivangua	UM 2	1.6	3.0	1,725	12,100
Mwenendega	UM 2	1.7	2.3	1,350	1,670
Ndundori A	LH 1	1.6	1.3	1,680	4,720
Ndundori B	LH 1	1.6	1.2	2,003	3,800
Ngurumo	UM 3	1.5	2.0	3,300	7,850
Mean		**1.4**	**1.7**	**2,994**	**6,988**
Total				**38,928**	**90,850**

†AEZ = Agroecological Zone: LH1 = Lower Highlands 1; UM 1 = Upper Midlands 1 (Tea-Coffee Transition Zone); UM 2 = Upper Midlands 2 (Coffee Zone); UM 3 = Upper Midlands 3 (Marginal Coffee Zone) (Jaetzold and Schmidt, 1983).

bed with an application of cattle manure a better advantage than polythene bag method and thus was recommended for on-farm propagation of *Calliandra calothyrsus* seedlings (O'Neill et al., 1997).

Average farm size during the 1997 long rainy season (Table 2) was 1.4 ha with an average of 1.7 cows per household. There were 39,000 seedlings planted on 178 farms; 43% of the 91,000 seedlings required by participating farmers. Mean farm size was somewhat smaller (1.1 ha) during the 1997 short rainy season than during the previous season (Table 3). Cow population was about the same as during the 1997 long rains with 1.4 cows per household. A total of 211 farmers from 15 community-based nurseries successfully transplanted 49,600 calliandra seedlings during this second season, but due to increased demand, this was a 56% shortfall of the required number of seedlings. In addition to Embu District, four group nurseries were established in Kirinyaga District and nine in Meru South District.

During the 1997 long rains, 44% of the niches selected by farmers could double as soil conservation structures in addition to fodder production niches. This increased to 57% during the 1997 short rainy season. Generally, farmers selected niches along existing terraces and contours within sloping fields for soil conservation. Secondary niches for soil conservation were on internal and external boundaries perpendicular to the slope.

Development of group or community nurseries and dissemination to farmers of calliandra fodder material for substitution of or supplementation to dairy meal began in January 1997. Field transplanting during the two rainy seasons of 1997 totaled 88,500 seedlings from these community-based group nurseries. Over 385 small-scale dairy farmers benefited from seedlings produced in their own group nurseries at quantities necessary to provide sufficient quality fodder for one cow over a period of one year. Based on the need for 500 seedlings per cow per year, sufficient seedlings were produced to support 177 cows. At a net benefit of US$150 per cow per year, this represents a contribution of US$26,550 into the community.

Table 3. Number of calliandra (*Calliandra calothyrsus*) seedlings planted plus additional seedling requirements during the 1997 short rainy season in 15 group nurseries in Embu, Kirinyaga, and Meru South District, Kenya.

Nursery	AEZ†	Farm Size (ha)	Cows	Seedling Planted	Seedlings Required
Jisaidie	UM 2	1.3	1.3	2,835	6,030
Kamiugi	UM 2	1.1	1.6	2,420	2,700
Karangi A	UM 2	0.7	1.2	3,217	3,220
Karangi B	UM 2	1.2	1.6	2,006	3,850
Kariari	UM 2	1.0	1.5	6,295	23,750
Kathangari	UM 2	1.2	1.0	2,470	2,300
Kathangari	UM 3	0.2	1.0	200	200
Kianjuki	UM 2	1.2	1.0	8,843	5,080
Kirurumwe	UM 3	1.0	1.7	3,121	6,500
Kivangua A	UM 2	0.9	2.0	2,964	7,500
Kivangua B	UM 2	1.0	2.6	3,395	12,260
Mwenendega	UM 2	1.5	1.6	1,640	1,330
Ndundori A	UM 1	2.8	2.3	3,850	4,750
Ndundori B	UM 1	1.3	0.8	2,350	3,100
Ngurumo	UM 3	0.8	1.5	4,008	6,100
Mean		**1.1**	**1.4**	**3,101**	**5,542**
Total				**49,614**	**88,670**

†AEZ = Agroecological Zone: LH1 = Lower Highlands 1; UM 1 = Upper Midlands 1 (Tea-Coffee Transition Zone); UM 2 = Upper Midlands 2 (Coffee Zone); UM 3 = Upper Midlands 3 (Marginal Coffee Zone) (Jaetzold and Schmidt, 1983).

There are approximately 400,000 smallholder dairy farmers in Kenya; each has about 1.7 cows per farm (Reynolds et al., 1996; Murithi 1998). The potential benefits, therefore, for adopting calliandra in the Kenya smallholder dairy sector, as measured in this paper, could amount to US $102 Million a year (400,000 households x 1.7 cows per household x $150). Calliandra also has 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, Tanzania, and Zimbabwe are testing calliandra and other fodder tree species and results are promising.

CONCLUSIONS

Test farmers in the Embu area are adopting calliandra as a fodder tree and farmer-to-farmer dissemination of seed is substantial. Through project initiatives, researchers are working with extension personnel and farmers to increase the availability of calliandra for fodder production. Group nurseries are capable of generating seedlings in quantities necessary for broad adoption. Farmer-to-farmer interactions are increasing demand for calliandra and efforts to establish group nurseries for local production while maintaining genetic diversity is becoming entrenched in the region. Fifty percent of the niches preferred by farmers for transplanting the fodder shrubs were on soil conservation structures and along the contour of sloping fields. As we approach the twenty-first century, dairy farmers in the Embu area are reaping the results of participatory research and development by generating income to address family needs, maintaining environmental quality, and contributing to the sustainable stewardship of their natural resource base.

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