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FARMERS' EXPERIENCES IN THE MANAGEMENT AND UTILISATION OF *CALLIANDRA CALOTHYRSUS*, A FODDER SHRUB, IN UGANDA

Philip Nyeko, Janet Stewart, Steven Franzel and Pia Barklund

Abstract

Understanding farmers' experiences and practices is important in facilitating the development and introduction of technologies that meet farmers' aspirations and are thus likely to be adopted by them. This paper documents farmers' experiences in the management and utilisation of an important agroforestry tree species, Calliandra calothyrsus, *in Uganda. Specifically the report provides information on farmers' knowledge, perceptions and practices in the cultivation and utilisation of calliandra; and their experiences of the species's pest and disease problems. We conducted a survey using a pre-tested questionnaire in three agroecological zones. Implications of the findings for scaling up the adoption of calliandra and agroforestry technologies, in general, are discussed.*

Research findings

- *Farmers' management and utilisation of calliandra are influenced by advice provided to them, mainly by projects promoting the species, as well as their own experience and innovations.*
- *Pests and diseases are a constraint to the cultivation of calliandra, but farmers lack advice on the pests and diseases that attack the species.*
- *There is a high potential for using calliandra, as a substitute for expensive dairy meal concentrates, in small-scale dairy enterprises as well as in goat, sheep, rabbit, pig, poultry and fish farming. Calliandra is also important for soil conservation, firewood, stakes, bee forage and boundary marking.*

Policy implications

- *Provision of planting material is key to the scaling up of important agroforestry species such as calliandra. Mechanisms are required for decentralised seed supply with clear policies on seed quality and pricing.*
- *As agroforestry technologies are developed and promoted, there is a need to incorporate information on the diagnosis and management of pests and diseases of the agroforestry components in dissemination packages.*
- *The profitability of cheap protein-rich fodder trees such as calliandra in dairy farming could be maximised through deliberate government policies to improve the processing and marketing of milk.*

Contact Details

Philip Nyeko is a Senior Lecturer at Makerere University. He can be contacted at the Faculty of Forestry and Nature Conservation, Makerere University PO Box 7062, Kampala, UGANDA. *Tel*: 256 41 543647 *Email*: nyeko@forest.mak.ac.ug

Janet Stewart is a Senior Research Associate at the University of Oxford. She can be contacted at Oxford Forestry Institute, University of Oxford, South Parks Road, Oxford OX1 3RB, UK. *Tel*: 44 1865 275126 *Email*: janet.stewart@plants.ox.ac.uk

Steven Franzel is an agricultural economist at the World Agroforestry Centre. He can be contacted at World Agroforestry Centre, PO Box 30677, Nairobi, KENYA. *Tel*: 254 2 524000 *Email*: s.franzel@cgiar.org

Pia Barklund is an Associate Professor at the Swedish University of Agricultural Sciences. She can be contacted at the Department of Forest Mycology and Pathology, PO Box 7026, SE-750 07 Uppsala, SWEDEN. *Tel*: 46 (0)18-67 18 74 *Email*: pia.Barklund@mykopat.slu.se

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Acronyms and abbreviations

AFRENA	Agroforestry Research Network for Africa
FORRI	Forestry Resources Research Institute, Uganda
ICRAF	International Centre for Research in Agroforestry
ITK	Indigenous Technical Knowledge
KARI	Kawanda Agricultural Research Institute
LVC	Lake Victoria Crescent
MPTS	Multipurpose Tree Species
NARO	National Agricultural Research Organisation, Uganda
NGOs	Non-Governmental Organisations
SDL	Southern Drylands
SHL	Southern Highlands
SIDA	Swedish International Development Cooperation Agency

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1 INTRODUCTION

Despite considerable progress in agroforestry research and dissemination over the last decade, the adoption and impact of agroforestry on smallholders' livelihoods is generally still modest in the tropics (Nair, 1997). The challenge here is to understand the farmers' situation and start from there. Thus it is important to understand whether research findings concur with farmers' experiences and innovations, and ways in which research outputs have been adapted and tailored to farmers' own needs. This information is important in understanding how to expand agroforestry technologies that have gained footholds, ensure access to planting materials for important species, and provide useful information on their management and utilisation. Understanding farmers' experiences is therefore important in the scaling up of technologies that meet farmers' aspirations and are thus likely to be adopted by them (Nyeko et al., 2002a).

In Uganda, one of the most promising agroforestry tree species is *Calliandra calothyrsus* Meissner (Mimosaceae), referred to as calliandra in this paper. Calliandra is a fast-growing nitrogen-fixing multipurpose tree species (MPTS) native to Central America and Mexico. It has been introduced in many tropical countries where it is an important component of agroforestry systems. In Uganda, calliandra has been intensively evaluated under agroforestry programmes since 1989 for a variety of products and services, including fodder, fuelwood, stakes for climbing beans, soil erosion control and soil fertility improvement (Peden et al., 1990; Wajja-Musukwe et al., 1998). The International Centre for Research in Agroforestry (ICRAF) through the Agroforestry Research Network for Africa (AFRENA) project, jointly implemented by the Forestry Resources Research Institute, Uganda (FORRI), initiated research on calliandra in Uganda. Since the mid-1990s, ICRAF and national partners have been actively involved in on-farm testing and promotion of calliandra in Kabale District in the Southern Highlands (SHL) and in Mukono and Wakiso districts, Lake Victoria Crescent (LVC), in Uganda, where initial estimates of adoption have been very encouraging, and indicate considerable scope for further expansion. In the same period, Vi Agroforestry project has spearheaded the promotion of calliandra in the Southern Drylands (SDL), particularly in Masaka and Rakai districts. The main objective of the Vi project is to improve the livelihoods of small-scale farmers in the Lake Victoria basin. The project is supported financially by the Swedish International Development Cooperation Agency (SIDA) and collaborates with other partners, including government and private agencies in implementing its activities.

ICRAF's calliandra dissemination has involved provision of free seedlings and training to selected farmers, and encouragement to individual farmers and farmers' groups to establish their own nurseries. Similarly the Vi Agroforestry project started by providing free seedlings and training to selected farmers, but currently encourages farmers to sow calliandra seed directly in the field. Both ICRAF and the Vi project buy calliandra seeds from farmers which they package and sell to other farmers or organisations. This approach encourages farmers to produce more calliandra seed as a source of income while keeping some for their own planting. However, the organisations still give out free seeds and/or seedlings to new farmers.

Because projects and organisations promoting calliandra have often provided farmers with limited planting materials (less than 100 seedlings each) for initial planting, many farmers find it necessary to expand their calliandra plantings in subsequent years to meet their demands for the shrub. In the case of dairy farmers, for example, up to 500 calliandra trees are recommended to feed one cow for a year on six kg of fresh calliandra daily (Roothaert et al., 1998). Gerrits (2000) noted that by 1999, 50%, 10% and 4% of 88 calliandra farmers in Kabale had planted calliandra for the second, third and fourth times respectively. However, very little is known about farmers' management of calliandra in Uganda. Gerrits (2000) reported that farmers cut calliandra at heights ranging from two to three feet irrespective of the different uses of the shrub but cutting frequency differed between the uses. On average, farmers prune calliandra trees which are used for fodder production six times a year. When the trees are used for soil conservation or fertility purposes, pruning is done only twice or thrice a year, and calliandra used for firewood is pruned only once a year in order to allow the plant enough time to grow (Gerrits, 2000).

According to Gerrits (1999), calliandra, a protein-rich fodder tree, is already widely used by smallholder dairy farmers in Uganda. Presently, the number of farmers growing calliandra in LVC (Mukono and Wakiso districts only), SDL (Masaka and Rakai districts only) and SHL (Kabale District only) is estimated at 2000, 20,000 and 3000 respectively. Many projects and non-governmental organisations (NGOs) are taking part in scaling up the promotion of calliandra in Uganda. Some

Table 1 Characteristics of agroecological zones used in this study

	Lake Victoria Crescent (LVC)	Southern Drylands (SDL)	Southern Highlands (SHL)
District	Mukono and Wakiso	Masaka and Rakai	Kabale
Mean annual rainfall (mm)	1750–2000	under 1000	1000–1500
Mean minimum and maximum annual temperature (°C)	12–29	18–32	10–23
Altitude (masl)	1000 –1200	1300–1600	1800–2800
Soils	Ferralitic clay loams	Ferralitic clay loams	Ferralitic soils characterised by red-colour loams and sandy clays

Classification according to the National Agricultural Research Organisation (NARO), Uganda.

NGOs such as Heifer Project International and Africa 2000 Network stipulate that farmers plant calliandra fodder supplementation before they will give them improved dairy cows. This approach has tremendously enhanced the dissemination of calliandra among beneficiaries of the dairy cows (Gerrits, 2000). However, one of the major constraints in scaling up the promotion of calliandra in Uganda pertains to lack of adequate information about farmers' knowledge, perceptions and practices in the management and utilisation of this important agroforestry species. Equally important has been the failure of some programmes to address areas where farmers' knowledge is inadequate. If scientists have to work with farmers to improve calliandra production and utilisation, they should recognise farmers' constraints and their existing technical knowledge (Morse and Buhler, 1997).

One of the major constraints to optimal productivity in agroforestry is pest and disease infestation (Boa and Bentley, 1998). There has been increasing evidence of pests and diseases on calliandra in the recent past. Singh-Rathore (1995) reported up to 15 species of phytophagous insects associated with calliandra from field visits to experimental sites in Burundi, Cameroon, Kenya and Rwanda. Gauhl et al. (1998) reported *Tragocephala guerini* White as a significant borer of calliandra branches in Cameroon. In Kenya, Kaudia (1990) attributed low seed production of calliandra or complete lack of seeds to the rose flower beetle, *Pachnoda ephippiata* Gerstaecker, feeding on calliandra flowers. In Uganda, a new and potentially threatening health problem has emerged on calliandra. It is characterised by die-back, wilting, poor vigour/stunted growth, leaf chlorosis, zigzagging of branches, premature flowering, and darkening and hardening of the branches, leading to the death of substantial parts of the tree (Maiteki and Owera, 1996; Simons, 2001). *Fusarium oxysporum* Schlecht., *F. solani* (Mart.) Sacc. and a *Phomopsis* species have been consistently isolated from infected calliandra samples, and could be responsible for the symptoms (Simons, 2001). An unidentified mealybug and a brown scale (*Saisettia* species), which are capable of causing significant damage on young calliandra seedlings, have also been reported on calliandra in Uganda (Simons, 2001). These infestations raise concerns of health risks as adoption of calliandra continues to expand. Unfortunately, there have been no studies assessing farmers' knowledge, perceptions and management practices against health problems of calliandra in Uganda.

This paper documents farmers' experiences in the management and utilisation of calliandra in Uganda with the aim of scaling up the promotion of the species. Specifically, the paper documents the following information about calliandra: (i) farmers' knowledge, perceptions, innovations and practices regarding its cultivation and utilisation (ii) their awareness and perceptions of research findings on the species and (iii) the problems they have experienced in managing and utilising it, with particular emphasis on pests and diseases.

2 MATERIALS AND METHODS

Study area

The study was conducted in three ecological zones in Uganda, namely Lake Victoria Crescent (LVC), Southern Drylands (SDL) and Southern Highlands (SHL) (Table 1) where farmers had substantial experience with calliandra. The LVC ecozone is characterised by the coffee-banana land use system, with a diverse and complex farming system and crop growing period of 90–270 days, and by intensive smallholder production of subsistence and cash crops, with land holdings ranging from 0.1–4.5 ha (NARO, 1995). Crops commonly grown in mixed cropping pattern include cassava, sweet potatoes, maize, groundnuts, beans and indigenous vegetables. Food crops are grown either at the edges or under the canopies of bananas, coffee and other scattered trees. Isolated fruit trees such as avocado, jack fruit and mangoes are also common within the banana-coffee fields. Some farmers grow tea, coffee, sugarcane and vanilla on a large scale. The main livestock kept include cattle, goats and poultry. Cattle are kept basically for milk, meat, manure and occasionally income. Other livestock such as goats, sheep, pigs and poultry are mainly kept for sale and home consumption.

SDL is characterised by short grassland where extensive grazing prevails. Scattered *Acacia* species grow on the communal rangelands and provide shade for animals. The bimodal rains allow crop growth throughout the year especially in parts of Ntungamo and Mbarara districts where bananas are grown. The agroforestry systems are mainly the extensive silvopastoral type where scattered *Acacia* trees are a common feature on communal grasslands. Barrier hedges are also a common feature especially in Mbarara District, as are *Eucalyptus* woodlots.

In SHL, the agricultural system is mainly based on production of annual crops, with land holdings ranging 1–3 ha. Farm size in Kabale District ranges from 0.3–2.4 ha with 28.3% of households having less than 1 ha (Aluma et. al., 1995). The most important crops are Irish potatoes, field peas, beans, sorghum, wheat, maize and vegetables (cabbage, carrots, tomatoes, eggplants, amaranthus, onions, cauliflower). Perennial crops include bananas, cassava, coffee and fruit trees. Temperate high value crops such as apples and grapes are being introduced. Dairy farming (in zero grazing units, free ranging and in fenced valley farms) is also important. The high population pressure has pushed people to cultivate on very steep fragile hillsides, destroying contour bands, and to practise continuous cultivation with very short fallow periods.

Research design and procedure

A total of 30 farmers who had grown calliandra for at least two years were randomly selected from each of the three agroecological zones, using lists of agroforestry farmers obtained from ICRAF (for LVC and SHL) and Vi Agroforestry project (for SDL). The selected farmers were interviewed from November 2002 to February 2003 using a pre-tested questionnaire. The interviews were conducted in the farmers' local languages (Luganda and Rukiga), and their responses carefully translated and recorded in English. To achieve this, research assistants from ICRAF and Vi Agroforestry project, who were conversant with calliandra farmers and fluent in both English and the local language in their respective zones, were recruited and trained to translate the questions to the farmers, and the farmers' responses to the principal researcher.

In order to maintain consistency, the researchers had to frame the questions according to the pre-tested questionnaire. The aim was to learn about the farmers' socio-demographic conditions, and their agronomic and utilisation practices in order to obtain a clear picture of the agro-ecosystem. Special emphasis was placed on the farmers' knowledge and practices in calliandra production and its utilisation as fodder. They were also asked to identify what problems they had in cultivating and utilising it, with particular attention to their awareness and control of damaging organisms. They were also questioned about their knowledge of research findings on calliandra and ways in which the research findings related to their experiences and practices.

Interviews were conducted at the farmers' homes or in the calliandra fields, where such fields were within a kilometre of a farmer's homestead and the farmer was willing to be interviewed on site. This enabled researchers to crosscheck the respondents' answers with field observations. It took an average of one to two hours to interview each farmer. After every on-farm interview session, at least 10 calliandra trees on the respondent's farm were examined for damaging insects and diseases. Insects on the species were sampled using a beating tray or by handpicking. All insect samples were preserved in 99.7% ethanol in vials for later identification and reference. Insect samples were identified at the Natural History Museum, UK while pathogens were isolated and identified at Makerere University and Kawanda Agricultural Research Institute (KARI), Uganda.

Data analysis

The survey data were analysed using an SPSS statistical package. Percentages, totals and means on selected variables were determined using descriptive statistics and cross-tabulation of either single or multiple responses.

3 RESULTS

Household and farm characteristics

Overall, 56% of the respondents interviewed in this study were women, but the majority (77%) of household heads were male. On average, there were about eight individuals per household in all the ecozones studied. The respondents were mainly of two tribes, the Baganda in LVC and SDL, and the Bakiga in SHL. The majority of respondents in the three ecozones were middle-aged (30–59 years old). Most farmers had either purchased or inherited their land. However, whereas up to 40% of the respondents owned both purchased and inherited farmlands in SHL, only 10% and 13% did so in LVC and SDL respectively. Average farm size ranged from 1.7 ha in LVC to 2.3 ha in SDL and SHL.

The farmers' rating of their five most important farm enterprises varied between the ecological zones. Important enterprises mentioned by at least 60% of the respondents included dairy cattle (83%), banana (70%) and cassava (66%) in LVC; banana (87%) and coffee (73%) in SDL; and sweet potato (100%), beans (87%), sorghum (77%) and vegetables (60%) in SHL. Sorghum, Irish potato and peas were reported as important only in SHL. Similarly, only farmers in LVC and SDL considered cassava and vanilla as important farm enterprises. Only one farmer, in LVC, mentioned *Catha edulis* (commonly called *khat* by English-speakers and *mairungi* in Luganda) and rated it as his most important farm enterprise because it brought in a high income.

Of the livestock kept by farmers, goats were the most common in SDL while improved cows were dominant in LVC and SHL. Over 65% of the respondents in LVC and SDL kept chickens, the majority of them being layers. In contrast, only 30% of farmers in SHL had chickens, predominantly the local free range type. All those farmers who had rabbits, ducks and laying chickens practised zero grazing. Across the three zones over 80% of respondents with improved cows practised a zerograzing system. Similarly, the majority of farmers in SHL (54%) zero-grazed their local cows, but most respondents in SDL either used free grazing (40%) or tethered (30%) their local cows. Whereas 100% of the farmers who owned sheep in LVC tethered the animals, all sheep owners in SHL used a free grazing system, grazing them together with local cows.

Overall, more women were involved in farm management (83% in LVC, 97% in SDL and 84% in SHL) than their husbands (53% in LVC, 67% in SDL and 63% in SHL). The husbands who managed their farms did so jointly with their wives. Less than 10% of the respondents had their farms managed by their children or relatives. One farm in LVC was managed by the son of its 80-year-old owner. At least 90% of females managed their farms on a full-time basis in all the ecozones studied compared to 81%, 80% and 62% of men in SHL, SDL and LVC respectively. The majority (54%) of farm managers were aged between 40 and 60, only 4% being less than 30 years old. With the exception of one male manager encountered in SHL, all the farm managers had some formal education. Most (56%) farm managers were primary school leavers with only one university graduate, from SHL.

Generally, the household characteristics of farmers interviewed in this study seem typical of small-scale farmers in the three zones, especially in LVC and SHL. The farmers selected from SDL were not nomadic pastoralists with communal grazing lands, often found in Mbarara, Sembabule and Ntungamu districts. The percentage of respondent farmers with improved cows was generally higher in all three zones than in the population as a whole, apparently because farmers with improved cows were targeted by organisations disseminating calliandra.

Cultivation of Calliandra

Establishment and expansion

Methods of cultivating calliandra differed between the ecozones (Table 2). Planting of nursery-grown seedlings was the most commonly used method in LVC and SHL, where calliandra was mainly promoted by ICRAF. In contrast, farmers in SDL who where mostly advised by Vi Agroforestry project used direct sowing. Although up to 43% and 67% of farmers in LVC used wildings (young seedlings that develop in the wild without the help of humans) in their second and third plantings respectively, only 7% of respondents reported using wildings in SDL and none reported this method in SHL (Table 2). Farmers either transplant wildings onto prepared sites or simply tend them where they have germinated. In SDL and SHL 80% and 77% of farmers respectively planted calliandra for the second time compared to only 47% of the farmers interviewed in LVC (Table 2). Similarly, more farmers planted calliandra for the third time in SDL (23%) and SHL (30%) than those in LVC (10%). A few farmers (10% in LVC and 17% in SHL) reported planting calliandra for the fourth time, and about 10% of the farmers claimed to have planted calliandra for more than four years.

The number of plants cultivated varied enormously between farmers. For example, during the first planting, it ranged from 10–500 trees in LVC, 50–200 in SDL and 10–1500 in SHL. On average, farmers planted the highest number of calliandra in their second planting, ranging from 134 trees per household in LVC to 301 trees per household in SDL (Table 3). The current (during the study period) average number of trees per household was highest in SDL (924 trees) followed by SHL (626 trees), and was lowest in LVC (362 trees).

Table 2 Methods used by farmers in their first, second and third plantings of calliandra

Method	Number of respondents								
	LVC			SDL			SHL		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Direct sowing	3	3	1	20	17	7	0	2	1
Nursery seedlings	27	5	1	11	6	0	30	22	8
Wildings	0	6	2	0	2	0	0	0	0
Total respondents	30	13	3	30	24	7	30	23	9

Some farmers used more than one planting method at a time

Table 3 Mean number of calliandra planted and their survival on different planting occasions

Time of planting	LVC			SDL			SHL		
	No. of resp.*	No. planted	Survival (%)	No. of resp.*	No. planted	Survival (%)	No. of resp.*	No. planted	Survival (%)
First planting	22	104 (112)	77	6	112 (49)	74	27	171 (293)	84
Second planting	9	134 (170)	96	3	301 (367)	-	21	144 (144)	90
Third planting	3	80 (104)	98	2	108 (131)	-	7	118 (166)	73

* number of respondents who knew the number of trees they planted in the 1st, 2nd and 3rd plantings
- number of survival tree not known to farmers

Generally, farmers reported a high (over 70%) survival rate (Table 3). However, whereas the majority of farmers in LVC and SHL could remember how many calliandra trees they had planted and how many survived, most farmers in SDL could not. The most commonly cited causes of mortality were dieback[1] and prolonged dry spells. A few farmers who sowed calliandra directly on banks of soil and water conservation ditches reported running water as damaging to seedlings. Some cases of seedling theft were reported in SDL and SHL, suggesting an inadequate supply of seedlings. Poor farm management, especially late weeding, was more commonly reported as the cause of tree mortality in the first planting than in the second and third plantings. This suggests that the farmers' experience in calliandra cultivation was an important factor in minimising mortality.

Planting niches

Farmers reported planting calliandra in several niches, most commonly on field boundaries in all the ecozones (Table 4). Among the three zones, scattered planting of calliandra in cropland was most practised in LVC, but was limited only to the first and second plantings. Planting along banks of soil and water conservation ditches was most reported in SDL. Although this practice was least reported in SHL, it appears to be gaining popularity among farmers as a greater percentage of them mentioned it for their third planting (22%) compared to the first (3%) and second (4%) plantings. Only farmers in SDL (14%) and SHL (11%) reported cultivation around beehives and this was done in their third planting, indicating that growing calliandra for bee forage is a relatively new practice in the ecozones studied.

The majority (69%) of farmers who scattered calliandra in cropland mostly did so to improve soil fertility (Table 5). On the other hand soil conservation was the most commonly cited reason for farmers' choice of field boundaries, banks of soil and water conservation ditches. Plantings around homesteads, in woodlots and intercropping calliandra with napier were predominantly for easy access to various products, including fodder, stakes and firewood, derived from the species. Less than 30% of respondents considered limited land as their major reasons for selecting the planting niches (Table 5).

Table 4 Farmers' choice of calliandra planting niches on different planting occasions

Niche	Number of respondents for each planting occasion per zone								
	LVC			SDL			SHL		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Field boundary	13	9	3	21	18	6	22	13	5
Scattered in cropland	10	4	0	3	3	0	1	4	1
Along conservation ditches	7	3	1	12	8	2	1	1	2
In napier	3	1	0	1	1	0	1	1	0
Home boundary	2	0	1	1	0	0	7	2	1
Fodder bank	2	1	1	0	1	0	3	2	0
Woodlot	1	0	0	1	1	0	1	4	0
Contour planting	0	1	0	1	1	0	7	8	2
Around beehives	0	0	0	0	0	1	0	0	1
Around fishpond	0	0	0	0	0	0	0	0	1
Total respondents	30	13	3	30	24	7	30	23	9

Multiple responses were possible as some farmers planted calliandra in more than one niche

Table 5 Farmers' main reasons for choosing different planting niches for calliandra

	Number of respondents					
	Scattered in cropland	Field boundary	Intercropped with napier	Woodlot	Around homestead	Conservation ditches
Soil fertility	11	13	0	1	0	2
Soil conservation	6	36	2	0	2	21
Limited land	4	9	1	0	1	0
Easy access	4	19	3	3	6	0
Windbreaks	3	0	0	0	1	0
Shade	2	1	0	0	0	1
Live fence	0	16	0	0	5	0
Boundary marking	0	5	0	0	1	0
Seed production	0	0	0	2	0	0
Easy management	0	0	2	1	0	1
Total respondents	16	66	7	6	11	22

Multiple responses were possible as farmers selected niches for more than one purpose

Table 6 Farmers' sources of calliandra planting material

Source of material	LVC 1st	LVC 2nd	LVC 3rd	SDL 1st	SDL 2nd	SDL 3rd	SHL 1st	SHL 2nd	SHL 3rd
	Number of respondents								
Projects	13	3	3	28	20	4	25	18	5
Government agencies	5	0	0	0	0	0	1	1	0
Farmer groups	2	0	0	0	0	0	1	1	1
Individual farmers	4	2	0	0	0	1	0	1	0
Own farm or nursery	1	8	0	3	9	3	2	3	5
Bought from market	5	0	0	0	0	0	1	1	1

Some farmers had more than one source of planting material on each occasion.

Planting advice and material

Table 6 shows the sources of calliandra planting material and advice regarding its cultivation. In the LVC zone these were mainly ICRAF and the Heifer project, especially with regard to the first planting. For the first planting in SDL and SHL the advice came predominantly from the Vi Agroforestry project and ICRAF respectively. However, in all the ecozones, more farmers planted calliandra on their own initiative and obtained planting materials (seeds and/or seedlings) from their own farms for the second and third plantings than they did for the first planting. Government agencies, farmers' groups and neighbours were rarely sources of advice or material.

Tending operations

Overall, farmers mentioned six tending operations for calliandra (Table 7). Nearly all those interviewed weeded, the majority (91%) using hand hoes. The first weeding was done in a period ranging from two weeks to six months after planting. However, up to 21% of farmers in LVC admitted they did not know when they first weeded compared to only 3% in SDL and SHL. The majority of farmers in LVC (35%) and SDL (55%) weeded one to two months after planting, while most (31%) of those in SHL did so after two or three months. Most farmers (54% in LVC, 33% in SDL and 38% in SHL) weeded whenever they felt it was necessary (no definite weeding frequency). For calliandra scattered in cropland, weeding was reportedly done simultaneously with companion crops.

Crown pruning was more practised in SDL and SHL than in LVC. Root pruning was mentioned only in SDL, but farmers in this zone did not apply manure. Most farmers who thinned calliandra in LVC (66%) and SDL (75%) carried out the first operation one to four months after planting, but the majority (78%) of those in SHL did so at least six months after planting. Early thinning (two to four months after planting) was carried out mainly on seedlings arising from directly sown seeds. Such seedlings were reportedly hand-pulled or scooped up with a panga, knife or hoe and used for beating up (restocking failed areas by further planting) or planting new sites.

Table 7 Tending operations carried out by farmers in different zones

Tending operation	LVC	SDL	SHL
	% of total respondents per zone (30)		
Weeding	97	100	97
Manuring	30	0	10
Thinning	20	67	30
Beating up (restocking failed areas)	10	53	20
Crown pruning	7	47	47
Root pruning	0	27	0

Calliandra cutting height varied between zones as well as according to its different uses. Most farmers in LVC (55%) and SHL (48%) cut calliandra for fodder at heights between 0.5–1 m, but the majority of those in SDL (59%) reported lower cutting heights for fodder (0–0.5 m). These farmers claimed that this produced more vigorous and numerous coppices, and that such stumps lasted longer than those cut to a height of more than 0.5 m. In cases where calliandra stands were left to mature for firewood, the commonly preferred cutting height ranged between 0–0.5 m in LVC (52%) and SDL (86%), but 1–2 m in SHL (50%). Similarly, the majority of farmers who used calliandra for stakes in SHL harvested the species at 1–2 m above the ground.

Except for weeding, the majority of the farmers who tended the crop reported receiving training on how and when to carry out these operations from the various organisations promoting calliandra in the different zones. When it came to weeding, up to 57% claimed to rely on their own experience with crops in general. None of them mentioned receiving advice on the tending operations from neighbours.

Pests and diseases

Awareness of pests and diseases

Pests and diseases were observed by 77%, 57% and 47% of the respondents in LVC, SDL and SHL respectively. Those mentioned by at least 10% of respondents in the three zones included scale insects, livestock, dieback and termites in LVC; scale insects, livestock, dieback, termites and weaverbirds in SDL; and livestock, dieback, and weaverbirds in SHL. Dieback was the only disease the farmers described and was more commonly reported in LVC than in the other two zones. Insect pests were reported by 59%, 40% and 20% of the respondents in LVC, SDL and SHL respectively. The most commonly mentioned were termites (27%) in LVC, and scales in SDL (17%) and SHL (7%). Two respondents in LVC observed scale insects on their calliandra but they admitted they did not know it damaged the crop. Weaverbirds were mentioned as damaging to calliandra seeds in SDL and SHL where some farmers grew the species for commercial seed production. Farmers mentioned cattle, goats, rabbits, pigs, turkeys and chickens as damaging. Livestock damage was more commonly reported in SHL and SDL than in LVC. One farmer, from SHL, reported rats damaging nursery seedlings. Two or three farmers mentioned other pests, including black ants, seed-boring larvae, aphids, mealybug, a wild animal (*ngabbi* in Luganda), moles (*efukuzi* in Rukiga), thieves and vandals as damaging to calliandra.

Generally, the majority of farmers who observed damage caused by scales and dieback rated the severity as low or moderate, but up to 40% of those who observed scale damage in SDL rated it as very severe. Termite damage was reported to be high by most (67%) farmers who observed the damage in SDL while 50% of farmers in LVC rated it as moderate. Only one farmer reported termite damage on calliandra in SHL, and rated the damage as low. In contrast, the majority of farmers rated livestock damage as very severe in all the zones. Farmers reported some variation in pest and disease severity with tree age. Damage by scales (75%), dieback (72%) and stem-boring insect (100%) were commonly reported to be most severe on mature trees (one to five years old). Weaverbird was reported as damaging to flowers, pods and seeds, while livestock, especially goats and cattle, were reported by 63% of farmers as causing severe damage at all growth stages of calliandra. A majority (58%) reported termite damage as most severe on calliandra less than a year old, but up to 33% considered coppices from stumps more than five years old as most severely damaged by the insect.

Seasonal variability in the severity of dieback seemed less obvious to farmers as 33%, 28% and 22%, reported the disease as most severe in the dry season, wet season and throughout the year respectively, while 17% of them were not sure of any variability. Similarly, 38% of farmers reported damage by scales as most severe in the wet and dry seasons, 13% considered it severe throughout the year, while 13% were not sure. However, the majority of farmers considered the damage by birds (50%), livestock (64%), stem-boring insect (100%) and aphids (100%) to be unvarying throughout the year. All farmers who reported damage by termites and wild animals considered these pests to be most damaging in the dry season.

The majority of farmers who observed calliandra pests claimed that they observed similar pests or disease symptoms on other tree species and/or crops (Table 8). A mealybug species, *Planococcus kenyae* (Le Pelley), reported by a farmer in SDL to be damaging to calliandra and coffee was sampled during the survey, and proved to be occurring on both crops. However, no sample of another mealybug species, *Saccharicoccus sacchari* (Cockerell), which one farmer claimed to have observed damaging sugarcane and calliandra, was observed on the latter during the survey. Nearly all farmers who observed dieback on calliandra claimed to have observed similar symptoms on coffee and banana. One farmer in SDL actually uprooted calliandra that she had planted on the boundary of a banana plantation for fear that the dieback disease she observed on the calliandra would spread to her banana. This indicates the need for urgent verification of farmers' perceptions of the occurrence of calliandra pests and diseases on crops.

Most farmers were not aware of the effects of different tending operations on the incidence of insect pests and dieback. A few claimed that weeding and regular cutting reduce the severity of scales and dieback. One farmer observed that planting calliandra in a banana plantation increases the severity of pod and seed damage caused by weaverbirds because the birds construct their nests on banana. Weeding and thinning were observed by most farmers to have no effect on the incidence of livestock damage on calliandra.

Pest and disease control

The majority of farmers who reported damage by scales (54%), termites (75%), black ants (67%) and livestock (79%) had attempted to control the pests (Table 9). However, control of dieback, which was most reported by farmers (32%), was attempted by only 40% of them. The farmer who reported damage by aphids and the

Table 8 Farmers' perceptions of the occurrence of calliandra pests on other trees and crops

Pest	Crop
Dieback	Coffee, banana, cassava, tomato, beans, irish potato, peas, sugarcane
Termites (Enkuyege, Emishwa)	Maize, groundnuts, cassava, grevillea, sugarcane, coffee, eucalyptus
Scales	Coffee, cassava, napier, eggplant, sugarcane,
Black ants (Ebisamunyu)	Avocado, green vegetables (Eswiga), beans
Aphids	Beans
Mealybug (Ntonyeze)	Coffee, sugarcane, peas, *Ficus natalensis*
Caterpillar	*Sesbania sesban*
Weaverbird (Ndegeya, Omushure	Beans, maize, vanilla, banana, sorghum
Wild animal (Ngabbi)	Cassava, napier, green vegetables, Tanzanian grass
Rats (Embeba)	Beans, peas
Livestock	Cassava, sweet potato, jack fruit, banana, sorghum, maize, beans
Thieves	Maize

Words in parentheses are the Luganda or Rukiga names of pests

Table 9 Number of farmers attempting to control pests on calliandra

Pest	No. of respondents who observed pest/disease	No. of respondents who attempted to control pest/disease
Dieback	29	11
Livestock	14	11
Termites	12	9
Scales	11	6
Weaverbird	6	2
Black ants	3	2
Vandals	3	1
Unknown wild animal	2	1
Seed-boring insect	2	0
Rats	1	1
Aphids	1	0

two reporting seed-boring insect damage did not attempt to control them. The farmers used a variety of methods against the different pests they observed. However, applying chemical pesticides (Ambush, Dusban and Salut) was mentioned only with regard to scales and termites. These chemicals were rated as highly effective, but one farmer noted that treated termite mounds are sometimes recolonised. Several cultural methods including pruning, intercropping and application of plant extracts, wood ash, and red pepper were reported against insect pests and dieback. The methods farmers considered effective against dieback included applying well-rotted cow dung around infected trees, and uprooting and burning them. The application of mixtures of (1) *Melia* leaves, goat urine, ash and red pepper or (2) ash, *Tephrosia* leaves and marigold leaves were seen as highly effective against termites. The farmer who intercropped calliandra with *Melia azedarach* considered this method moderately effective against termites. Cutting of trees attacked by scales was reported to be moderately effective in controlling the insect. Similarly, two farmers rated the application of ash on the stems of trees attacked by scales as moderately effective against the pest. However, one farmer considered this method ineffective.

Farmers tethered their livestock and/or used zero or paddock grazing to control any damage. Neighbours with destructive livestock were either warned or, where such warnings were ignored, reported to local councillors for legal action. Only one farmer received some advice in relation to pest problems on calliandra. This farmer claimed to have been advised by ICRAF to remove dieback-infected trees in order to control the disease.

The farmers who made no attempt to control the pests they had observed on calliandra cited a number of reasons for their inaction. Up to 43% of those who did not control dieback said they did not know the causal agent of the disease. In contrast, only three farmers mentioned lack of money to purchase chemical controls. A few farmers were afraid of applying chemical pesticides against scales and dieback for fear of contaminating the calliandra they were using as animal fodder. This indicates the importance of not only recommending pesticides to farmers but also educating them on their side effects.

Utilisation of Calliandra

Farmers planted calliandra for a number of uses, the most highly rated being fodder in all the zones (Table 10). The uses of calliandra mentioned by at least 60% of the respondents in each zone included fodder, firewood and soil erosion control, plus soil fertility improvement and stakes in SHL. Although all the farmers claimed to have used calliandra to control soil erosion, they generally gave low scores to this benefit. Using calliandra as stakes, mainly for climbing beans, was largely confined to SHL (83% of respondents). Only one farmer in SDL used the species for staking banana and none mentioned this use in LVC (Table 10). Two farmers in SDL planted calliandra around their apiaries for bee forage. Similarly, one farmer in SHL planted it around his fishpond both to feed the fish and to keep the pond from silting up through soil erosion.

Calliandra as fodder

Farmers fed calliandra to a wide range of livestock. All those who had improved cows or rabbits used it as feed, as did the only farmer in the survey to keep fish. In contrast, nobody fed calliandra to ducks and turkeys, although one farmer in LVC mentioned feeding ducks with dry calliandra leaves during a preliminary survey for this study. The most important use of calliandra was as fodder for improved cows: in all three zones, it was used by all those respondents who owned improved cows. The proportion of farmers who fed

Table 10 Uses of calliandra mentioned by farmers in LVC, SDL and SHL

Use	LVC		SDL		SHL	
	No. resp.	Mean score	No. resp.	Mean score	No. resp.	Mean score
Fodder	29	6.0 (0.0)	27	5.6 (0.8)	24	5.4 (1.06)
Soil fertility improvement	13	4.4 (0.51	18	3.7 (1.07)	22	4.5 (1.14)
Firewood	25	4.7 (0.72)	29	4.4 (1.15)	24	3.4 (1.13)
Soil erosion control	30	1.7 (0.45)	30	1.2 (0.43)	30	1.2 (0.37)
Stakes	0	0.0 (-)	1	1.0 (-)	25	3.8 (1.03)
Others	5	4.2 (0.83)	10	3.3 (1.16)	3	1.7 (0.58)

Others refer to bee forage, construction material and boundary marking. Figures in parentheses are standard deviations. Uses ranked first, second, third, fourth, fifth and sixth by farmers received scores of 6, 5, 4, 3, 2, and 1 respectively calliandra to local cows, bulls, calves, goats, sheep, chickens and pigs, however, varied between zones. For example, whereas all farmers who had sheep in LVC and SDL fed them calliandra, no farmer in SHL did so. Over 80% of farmers who fed the species to their livestock rated its palatability as very good. The exception was the 20 farmers who used it as feed for pigs, where 50% rated its palatability as very good, while 40% considered it only fairly palatable. Those who rated calliandra as very palatable to pigs observed that they need to be fed the species continuously for some time in order to adapt to the fodder.

Overall, the majority (89%) of the farmers harvested calliandra for fodder whenever it was ready, 10% harvested it only in the dry season and 1% only in the wet season. Of the farmers who used it for fodder 33% had enough to harvest throughout the year, while 28%, 20% and 13% of the farmers could harvest continuously for fodder between one week and one month, one to three months and three to nine months respectively. A few of the farmers did not know how long their calliandra could last under continuous feeding to their animals.

The majority (over 80%) of farmers fed calliandra within one hour of cutting it to all types of livestock, except chickens. However, the methods of preparing the fodder varied between livestock types. Chopping up the leaves and soft stems was the most commonly reported method for feeding cattle, while goats, sheep and pigs were mostly given whole calliandra stems and leaves. The farmers claimed this latter method is very good, not only because it allows the animals to peel off and consume the bark from old stems easily, but also because the debarking ensures rapid drying of the stems for use as firewood. The farmers also considered this method to be less labour-intensive than chopping up the plant. The three farmers who fed calliandra to their chickens dried the leaves for more than a day and mixed them with poultry feed. One farmer in LVC practised a method of making silage that involved fermenting calliandra with other fodder species, which he fed to his improved cows in the dry season. In this method, the farmer said a mixture of fresh fodder trees, shrubs or grass were wrapped in a polythene sheet and buried underground to ferment for about three months. He said he had learned about this method through a group training of farmers conducted by experts from Makerere University.

Most (76%) farmers mixed calliandra with other fodder when feeding their cows, using a variety of fodder, including several grasses, tree species, crop residues and meal concentrates. Napier was the most commonly cited fodder in all the ecozones, followed by calliandra. Only farmers from SHL ranked pigeon pea and Kikuyu grass among their five most important fodders, and they rated these highly. Similarly, banana peel was more commonly fed to cows, and more highly rated in SDL and SHL than in LVC. Other commonly mentioned fodder included potato vines (in all the ecozones), banana stems (in SDL and SHL), *lablab* (LVC and SDL), Tanzanian grass (LVC and SDL) and *Vernonia amygdalina* (LVC and SDL).

Farmers fed meal concentrates to cows only. Whereas 73% of farmers who had cows in LVC fed the animals with dairy meal concentrates, only 20% and 21% did so in SDL and SHL respectively. Most of the farmers (52%) used mixed concentrates (maize, wheat, soybean or cotton cake), and 24%, 16% and 4% of them used only maize bran, wheat bran and cotton cake respectively. One farmer used the dregs from local brews. All those who fed dairy concentrates to their cows used them as supplements to calliandra. Those who did not feed their cows on dairy concentrates cited a number of reasons for doing so. These included the high cost of the concentrates compared to returns from milk (33%), lack of money to buy dairy concentrate (30%), enough fodder available (10%), waiting for cows to deliver (8%), dairy concentrate does not increase milk production (3%), dairy concentrate made the cows infertile (3%), and dairy concentrate not profitable for local cows because of their naturally low milk production (3%).

Farmers fed calliandra to their cows during both lactating and dry periods. Overall, 61% of the farmers had cows producing milk, 85% of whom were selling their milk. Mean milk price per litre in LVC, SDL and SHL averaged USh.447, 344 and 219, and ranged from USh.300–600, 300–400 and 150–300 respectively (US$1=USh.1850, November 2002 to February 2003). The farmers who did not sell their milk considered their production to be inadequate for sale, and consequently used it for domestic consumption only.

Milk production during peak lactation reported by farmers averaged 11.4 litres/cow/day, but ranged from as low as 1 litre/cow/day from a local cow to 26 litres from an improved cow. The majority of farmers who fed calliandra to cows (86%) observed that the species increases milk production, but a few of them (5%) did not know this. Some 8% of the farmers mentioned increased butter content of milk from cows fed on calliandra. Most farmers (95% in LVC, 78% in SDL and 100% in SHL) considered calliandra as profitable in their dairy enterprise. Only one farmer, in LVC, was not sure of the profitability of calliandra in dairy farming.

Farmers' plans for future planting of calliandra

The majority of farmers (77% in LVC, 83% in SDL and 97% in SHL) wanted to plant more calliandra. The most commonly cited reason was the need for all possible benefits from the species (41%) followed by expectation of more livestock (27%), lack of fodder (13%), income generation (8%), need for continuous fodder supply (5%), and availability of adequate land (3%). The few farmers who were not interested in planting more calliandra either claimed to have enough of the species (36%) or were discouraged by lack of land (18%), loss of livestock that had been fed on calliandra (18%), theft of seedlings (9%), couch grass (9%) or dieback (9%).

The mean number of calliandra plants that farmers required for future cultivation varied between zones, the highest being 2218 (range: 100–10,000) trees per household in SDL followed by 832 (range: 20–10,000) in SHL and 356 (range: 30–2000) in LVC. Most farmers wanted to plant it along field boundaries. However, in SDL farmers mostly preferred to plant calliandra along the banks of conservation ditches, while future contour planting of calliandra was mostly mentioned in SHL. In LVC and SDL, the majority of farmers who wanted to plant more calliandra had planned to obtain seeds from their own farms, but most of those in SHL (89%) were expecting free seeds from organisations, especially ICRAF and Africare, promoting calliandra in the zone (Table 11). Farmer-to-farmer transfer of calliandra seeds does not seem to be much practised; only one farmer had planned to borrow seeds from neighbours. One farmer in LVC claimed to be interested in planting more calliandra, but did not know a source of seeds for the next planting.

Researchers' assessment

According to the researchers, general farm management was good in most of the farms visited during the study (52% in SHL and 55% in LVC and SDL). The farms described by researchers as having excellent management ranged from 25% in LVC to 44% in SHL, and those that had fair management ranged from 4% in SHL to 17% in LVC. Researchers visited the calliandra gardens of all the farmers interviewed, except one farmer each in LVC and SDL, and three farmers in SHL. Most farmers (57% in LVC, 64% in SDL and 72% in SHL) had good or excellent calliandra fodder management, but up to 31% and 7% of those in LVC were rated as having fair and poor fodder management respectively.

Pest and disease incidence

Although the researchers observed a number of pests and diseases on calliandra during this study, their incidence was generally low. Dieback was the most common disease problem observed, the majority of which occurred in LVC (50%) followed by SDL (34%) and SHL (16%). The pathogens isolated from calliandra samples with dieback symptoms were *Fusarium oxysporum* and a *Phomposis* species. Only one termite species, *Macrotermes subhyalinus* (Rambur), was observed damaging calliandra. Most (63%) of the damage by this species was observed in LVC but only one farm in SHL. Damage by weaverbird was observed only on seed-producing calliandra trees, the majority of which were in SDL. However, a bird species called *Ekyiswa* in Rukiga was observed causing serious damage in one nursery in SHL during the preliminary phase of this study. The bird pecked off the shoots/ cotyledons of all newly germinated/germinating calliandra in the nursery.

Table 11 Sources of calliandra seed for farmers' future planting

Seed source	Number of respondents LVC	SDL	SHL	Total
Free supply from organisations	4	16	25	45
Own farm	13	20	9	42
Buy from open market	5	1	0	6
Borrow from neighbour	1	0	0	1
Not sure	1	0	0	1
Total respondents	23	25	28	76

Numbers do not sum up because of multiple responses

4 DISCUSSIONS

Establishment and management of calliandra

Generally, calliandra can be established using a variety of methods, including nursery seedlings, direct sowing, stump sprouts, and vegetative cuttings from succulent stems or roots cultivated in propagation boxes (Roshetko et al., 1997). In this study, there were marked differences in planting methods used by farmers in the different zones, the choice being apparently influenced by the sources of planting advice and materials. Whereas Vi Agroforestry project appeared to promote direct sowing of calliandra in SDL, ICRAF-advised farmers in LVC and SHL mostly used nursery-grown seedlings to establish the crop. The high use of wildings reported for the second and third plantings in LVC was largely attributed to farmers' own innovations. The farmers in this zone, particularly those from Wakiso District, reported lack of follow-up activities by the organisations or individuals that introduced calliandra for their first planting. This may also explain the relatively low number of farmers who had planted calliandra for the first, second and third times in LVC compared to those in SDL and SHL. Defining an adopter as a farmer who has expanded at least once and has more than 100 trees (Franzel et al., 1999), 43%, 77% and 80% of the farmers interviewed in LVC, SHL and SDL could be called adopters.

In spite of the variety of methods used to establish calliandra, farmers in the study generally reported high seedling survival (73–98%). This is consistent with that reported in Kabale District, Uganda (Gerrits, 2000) and in central Kenya (Franzel et al., 2003). Although the survival of directly sown seeds is high in SDL, this method generally requires larger quantities of seeds than would be needed to raise equivalent seedling stock in nursery conditions (Katende et al., 1995). A number of farmers cited poor management and prolonged dry spells as some of the main causes of their tree mortality. It is generally known that all calliandra planting materials are susceptible to early competition (Roshetko et al., 1997). Therefore, intensive weed control should be practised until the plants are well established. In addition, seedling mortality attributed to a prolonged dry spell could be minimised by planting in the field at the beginning of the rainy season.

This study has shown that farmers' reasons for choosing calliandra planting niches are varied, reflecting the diversity of products and services they need from the shrub. The need for soil fertility improvement, soil and water conservation, ease of access and management and protective services were apparently crucial in the choice of planting niches. However, it is surprising that only 30% of the farmers considered limited farm size as a major factor in choosing their planting niches, considering the fact that the average farm size was generally low (1.7–2.3 ha) in the ecozones studied. This may be indicative of their reluctance to devote separate areas of the farm to calliandra stands. Understanding such factors is important to researchers and extension agents when selecting niches for on-farm trials. Franzel et al. (2003) observed that the niches for calliandra are sometimes determined by the farmers themselves, and sometimes by researchers and farmers together, as when an on-farm trial concerns a particular niche.

The cutting height of between 1–2 m mentioned by the majority of farmers in SHL for firewood and stakes is apparently too high for optimal biomass production. According to Roothaert et al. (1998), the height at which the first cutting is made should be low (0.5 m) to induce the tree to spread at the base. Later cutting heights can be higher: 0.5–1m, as the farmer prefers. When calliandra is grown next to or between food crops, however, a farmer might want to cut it at a lower height to minimise the shading effect on the crops. Calliandra can be cut successfully even at ground level.

The findings of this study indicate that the majority of farmers used simple hand tools including pangas, hoes, slashers, knives, secateurs, axes and dibbles for various management operations, but some farmers simply snapped off branches and hand-pulled seedlings during crown pruning and thinning respectively. Although breaking off branches by hand may save time, the use of sharp tools such as pangas and secateurs is recommended for pruning as they make a cleaner cut, thus promoting regrowth and reducing the risk of pests and disease attack on the shrub (Franzel et al., 2003). For example, a number of pathogens has recently been found associated with pruning wounds on several agroforestry tree species in Kabale District, Uganda (Nyeko, 2003). Similarly, hand-pulling seedlings when thinning for transplanting, as was commonly reported for directly sown seeds in SDL, is not recommended as this may damage seedling roots and thus create entry points for opportunistic pathogens. Such seedlings could be dug up with a panga, hoe or spade while maintaining soil enclosing the root system in order to facilitate establishment of the seedling upon transplanting.

Pests and diseases

Information about farmers' knowledge of calliandra health problems is generally scant in the literature. In this study, the farmers reported a number of pests including insects, mammals and birds, and dieback disease. This suggests that pest attack on the tree species was, in general, widespread in Uganda. Of the pests farmers reported, scales, dieback and livestock damage seemed common to all the zones studied. However, marked differences were observed in farmers' awareness of pest problems in the different zones, indicating patchy distribution of some pests. For example, termites were more often mentioned as a pest on calliandra in LVC and SDL than in the cooler SHL. Differences in pest awareness among farmers may also be due to variation in their main objectives in cultivating calliandra. For example, farmers growing calliandra for fodder and soil fertility may not consider weaverbirds, which damage pods and seeds, as a major problem, yet the bird could be a serious pest to those cultivating the shrub for seed production.

The farmers demonstrated a good knowledge of local pest control methods, especially against scales, termites and dieback. Various parts of plants and plant extracts are known to be either toxic or repellent to pests of crops and trees, and are widely used by small-scale farmers. For example, extracts from plants such as neem (*Azadirachta indica*), red pepper, *Tithonia* species, *Tephrosia vogelii* or wood ash, and cow dung and urine have been used to control termites in the field (Wardell, 1987; Logan et al., 1990). There has, however, been no published report on the use of such products against scales and dieback on calliandra, possibly because of the relatively recent appearance of these health problems on the shrub. In this study, farmers reported the application of well-rotted cow dung around infected trees, and uprooting and burning infected trees to be effective against dieback. In addition, farmers rated mixtures of *Melia* leaves, goat urine, ash and red pepper or ash, *Tephrosia* and marigold leaves as highly effective against termites. Ash was reported to be moderately effective against scales. Research is necessary to verify the potential benefit of using such indigenous methods and to establish specific recommendations for their large-scale utilisation in agroforestry. In Kenya, Roothaert et al. (1998) recommended spraying scales on calliandra with a washing detergent dissolved in water, but the authors neither indicated the name of the detergent nor its required dose and frequency of application for effective control of the pest. Although some farmers reported spraying their calliandra with chemical insecticides in this study, some of them were interestingly reluctant to do so, for fear that pesticide-treated fodder could be dangerous to their animals. This indicates the importance of educating farmers on the side effects of pesticides when recommending their use.

The fact that only one farmer had received some advice on calliandra pest problems is alarming. This indicates that the majority of farmers relied on their own experience in detecting and managing pest problems rather than being advised on potential problems prior to planting. Clearly, agricultural extension agents need to put more efforts into transferring pest-related information, such as potential species of pest, damage symptoms, factors contributing to pest outbreaks, effects of pest infestations, and possible solutions to pest problems, to farmers in order to strengthen their ability to identify and manage pests. However, it should be emphasised that information programmes need not so much stress that outbreak infestations exist, as critically assess the ecological and economic implications of outbreaks so that farmers can develop informed opinions about different pests (Nyeko et al., 2002a). For this to be effective, dissemination officers must be knowledgeable about the identity and management techniques of a given pest species or complex. As this is not often the case (Nyeko, 2001), it may be necessary for pest control programmes to commence with training of trainers to ensure that correct information is delivered to and received from farmers. This way, dissemination officers can act as liaisons between scientists, pest management specialists, and farmers while respecting each group's idiosyncrasies (Dix, 1996).

The biological survey showed a number of potential insect pests on calliandra although none had high damage incidence. However, single field visits, as conducted in this study, may not give a clear picture of pest problems since pest populations generally vary markedly over time (Nyeko et al., 2002b). Insect species such as *Macrotermes subhyalinus* and *Pulvinarisca jacksoni* that were observed feeding voraciously on calliandra, but with low incidence, may become more important as cultivation of calliandra intensifies in Uganda. Therefore regular monitoring is required to assess the population and damage dynamics of such pest species, and also to identify new important species that may emerge on calliandra.

Another concern is the occurrence on calliandra of insects known to be serious pests of crops or other multipurpose tree species. Particularly noteworthy in this study is *Aphis fabae*, known to be a serious pest of some crops and trees. In southern Malawi, Sileshi et al. (2000) recorded *A. fabae* feeding on *Arachis hypogeae*, trees including *Cajanus cajan*, *Gliricidia sepium* and *Sesbania sesban*, and some weedy species. Populations of such pests, particularly on annual crops, may be increased by the presence of calliandra as the latter, being perennial, can provide a ready food source for the pests in periods when the crop hosts are off-season (Mchowa and Ngugi, 1994; Singh-Rathore, 1995).

A potentially devastating disease of calliandra is dieback. The primary cause of this disease was not obvious due to a complex of fungal species isolated from diseased specimens. The isolation of *Fusarium oxysporum* and a *Phomopsis* species is consistent with earlier diagnosis of similar specimens from Uganda (Simons, 2000), suggesting that one or both of the pathogens are the primary causes of the disease. Roothaert et al. (1998) reported *Nectria ochroleuca* as the cause of similar dieback symptoms on calliandra, but this fungus was not isolated in the present study. Clearly, an inoculation test is urgently required to establish the cause of the dieback disease. In addition, screening trials incorporating calliandra provenances and species from different origins are necessary to determine if genetic resistance against the disease exists in other calliandra species and/or provenances. Furthermore, farmers' perceptions of the occurrence of calliandra dieback on coffee and banana need urgent verification.

Utilisation of calliandra

The high palatability of calliandra to various livestock, including cattle, goats, sheep, rabbits and chickens reported in this study concurs with reports by Roothaert et al. (1998) and Franzel et al. (2002). The reason for the relatively low palatability of calliandra to pigs is not clear, but some researchers have hypothesised low digestibility of the shrub for pigs (Roothaert et al., 1998) because monogastrics have trouble metabolising the large amount of tannin in calliandra. Only one farmer reported feeding calliandra to fish, apparently because very few farmers owned fishponds. With the recent emphasis on small-scale fish farming through the Plan for Modernisation of Agriculture (PMA) in Uganda, however, the demand for calliandra in fish feeding is likely to increase in the near future.

Over 80% of the farmers interviewed in this study fed their animals within an hour of cutting the crop. This is consistent with the recommendation to feed only fresh leaves (Roothaert et al., 1998). However, recent research show that calliandra can be fed fresh, wilted or dried (Stewart et al., 2000). Roothaert et al. (1998) observed that drying calliandra can increase voluntary intake by sheep. Fermenting it, as reported by one farmer in LVC, seems particularly suitable for farmers with a limited number of trees as this could ensure a continuous supply of fodder in the dry season.

The average milk production of 11.4 litres/cow/day during peak lactation, reported by farmers in this study, is rather low. Such low milk production is common for cows kept by smallholder farmers due to poor composition of the fodder (Gerrits, 1999). In this study farmers mentioned using several grasses, tree species and crop residues as fodder for dairy cows. Although fodder such as grasses, banana stems, potato vines and maize straws provide roughage, their nutritive value is generally low. For a farmer to obtain high economic returns, lactating cows should therefore be fed on protein-rich supplements such as tree fodder. Feeding tree leaves such as calliandra (with crude protein levels of 20–25% of dry matter) to dairy cows can be profitable because it substitutes for relatively expensive dairy meal, as well as increasing the production and fat content of milk. However, there is a need for deliberate government policies to improve the processing and marketing of milk in order to maximise the profitability of such innovations.

5 CONCLUSIONS

Although this study focused only on calliandra in Uganda, its findings have implications for scaling up agroforestry technologies in several tropical countries. It is clear from the study that there is a high potential for scaling up the adoption of calliandra in Uganda, farmers' adoption of which is influenced not only by a number of organisations promoting the shrub, but also by their own experiences with the species. The diversity of extension providers, ranging from government and private agencies, to NGOs and the academic sector, gives farmers a wide choice of information sources to support the long-term sustainability of their agroforestry farming practices. For successful scaling up of such technologies, however, there is a need for strong partnerships among the stakeholders to support local farmers' organisations and promote farmer-to-farmer extension for sustainability of the interventions.

Provision of seed and planting material is key to successful scaling up of agroforestry. In our study, some farmers were expecting organisations promoting calliandra to supply them with free calliandra seed for future planting. Such farmers should be trained and encouraged to produce and harvest seed to meet their own needs. In addition, mechanisms are necessary for a decentralised seed supply initiative. In Uganda, local governments, at sub-county level, are incorporating agroforestry in their development plans and budgets. This provides a good opportunity for the production and dissemination of planting materials. For example, such local government plans could include establishment of community tree seed orchards and nurseries aimed at improving availability of planting materials to farmers. However, there is a need for special attention to be paid to seed quality and pricing. The current agroforestry tree seed marketing by several NGOs in Uganda indicates a rather erratic pricing policy. In addition, farmers do not seem to be aware of the actual market values of seeds of exotic tree species such as calliandra, apparently because they are as yet new commodities.

Lack of advice to farmers on pests and diseases of calliandra is a looming constraint in scaling up its adoption. Such missing links can seriously affect the credibility in the eyes of farmers not only of agroforestry technologies, but also of the scientists and organisations promoting these technologies. Farmers rely on their indigenous technical knowledge (ITK) to control pest and disease problems on calliandra. Although work on ITK has shown that under certain circumstances farmers know more than scientists, we must not let this blind us to the fact that in other situations they do not have some of the vital information that would help them understand the rationale behind the development of pest and disease control measures. For example, farmers' lack of knowledge of the cause of calliandra dieback in our study indicates that their attempts to control the disease were based on trial and error, the efficacy of which requires verification. As agroforestry technologies are developed and promoted, there is a need to integrate pest diagnosis and management techniques into the scaling-up process in order to improve farmers' pest management practices.

The suite of pest and disease problems observed on calliandra in our study is a pointer to the need for systematic observations on pests and diseases in ongoing agroforestry research. In this way, specialists may identify pest problems that could be alleviated through agroforestry practices and develop corresponding experimentation programmes in cooperation with agroforestry scientists and farmers. For example, greater diversification of fodder shrubs, with emphasis on screening indigenous species identified by farmers, could reduce the risk of pest and disease attacks and thus improve feed quality and reliability.

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ENDNOTE

1 Farmers did not know the name and cause of the disease, but they either described some of its typical symptoms or showed the diseased trees to researchers during the field surveys.

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