Adoption of forage legumes: the case of *Desmodium intortum* and *Calliandra calothyrsus* in central Kenya

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Abstract

The benefits of integrating legumes into napier-based fodder systems for smallholder dairy systems in Kenya have been demonstrated. A case study is presented on recent activities to introduce *D. intortum* cv. Greenleaf and *Calliandra callothyrsus* in Kenya and their contribution to DM yields of fodder crops and animal performance. Experience with the participatory introduction of herbaceous and shrubby legumes into farming systems and factors affecting adoption of the legumes and methods used in an attempt to overcome constraints are discussed. Availability of planting material and ease of propagation were critical issues that needed to be addressed before farmers would adopt the technologies. Participatory development and evaluation of forage legume technology may be the key to improving adoption of forage legumes amongst smallholder farmers in central Kenya.

Introduction

Central Kenya constitutes 18% of the land area of the country but includes about 64% of the human population. Population density ranges from about 100 persons/km^2 in the dry lowlands to more than 1000 persons/km^2 in areas with high agricultural potential (CBS 1994). Agriculture is the main economic activity, with coffee (medium to low altitude) and tea (high altitude) as the major cash crops. The farming system is predominantly mixed; dairy production is especially important. In a farm survey (Staal *et al.* 1998), farmers ranked dairy production second only to cash crops in economic importance.

In Kenya, about 80% of marketed milk comes from smallholder mixed farms (Mbogoh 1984; DANIDA/MoLD 1991) which are mainly family farms with less than 10 ha of land (Gitau *et al.* 1994) and fewer than 10 dairy animals (MoLD 1985; MoA 1987). Due to the high human population pressure, farms are small with average holdings of 0.9–2.0 ha/household (Gitau *et al*. 1994; Staal *et al.* 1998) and are rapidly decreasing in size due to subdivision. Animals are therefore confined in stalls and fed on napier grass (*Pennisetum purpureum*) in 'zero-grazing' production systems. Approximately 80% of dairy animals in central Kenya are kept in these systems (Staal *et al*. 1998). The importance of the dairy enterprise in smallholder farms has increased in recent years due to liberalisation in the dairy subsector, which has resulted in the redistribution and increase of the overall social and economic benefits of market-oriented smallholder dairying (Omore *et al.* 1999). This, coupled with low cash crop prices, has made smallholder dairy production an important income earner for smallholder farms in Kenya.

Sources of livestock feed in central Kenya

Planted forages, the maize crop, cereal residues, natural pasture and grass harvested from public utilities (*i.e*., road reserves, school compounds *etc*.) are the major sources of livestock feed in central Kenya. As the size of land holdings has declined due to subdivision, the contribution of pasture to livestock production has declined. Therefore, most livestock feed comes from planted forages and cropped land. Apart from the maize crop, which is discussed below, bean haulms, weeds and fodder crops planted on soil conservation terraces are a major source of livestock feed on many farms. Even on farms where animals are grazed, fodder (including crop residues gathered from the farm) is usually the main source of feed and not pasture (Staal *et al*. 1998).

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Napier grass is the main fodder crop in central Kenya and is grown by more than 70% of the smallholder farmers in the area (Stotz 1983; Potter 1987; Bayer 1990; Staal *et al*. 1998). Stotz (1983) estimated that 240 000 ha or 4% of the total arable land on smallholder farms in Kenya was under napier grass. A survey in Kiambu district in central Kenya showed that, on average, households keeping cattle had 0.2 ha planted with napier grass (Staal *et al*. 1998); this represents approximately 15% of all arable land on these smallholdings. Data from longitudinal recording of 21 farms in Kiambu indicate that over 40% of the dry matter (DM) available to dairy cows in the area comes from napier grass (Table 1).

Table 1. Sources of livestock feed in central Kenya.

Source of feed	Proportion of overall DM available
Napier grass	40.9
Dry maize stover	17.1
Concentrate feeds	12.2
Grass	7.6
Weeds from cropped land	6.0
Maize thinnings	3.3
Green maize stover	3.0
Banana pseudostems	2.6
Poultry litter	1.7
Banana leaves	0.8
Banana thinnings	0.6

Source: Smallholder Dairy Project (SDP; longitudinal recording in Kiambu district) unpublished data.

Maize is a staple food crop in central Kenya, and has become increasingly important as a source of fodder on smallholder farms. The maize crop supplies approximately 23% of the DM available to dairy animals in central Kenya (Table 1), in the form of dry maize stover, thinnings and green stover. Methu *et al*. (1996) estimated that farmers grow an average of 0.36 ha of maize per season, from which they harvest 0.9 t of maize stover. Therefore, with 2 seasons in a year, approximately 1.8 t of maize stover is harvested. Farmers keep an average of 2 dairy cows in central Kenya (Methu *et al*. 1996; Staal *et al.* 1998). Therefore, sufficient maize stover is produced to feed these animals for 3–6 months; nevertheless, intake and utilisation are limited by the inherent characteristics of maize stover. Currently, maize stover provides about 17% of the DM available to dairy cows (Table 1).

Maize thinnings and green maize stover form about 6% of the DM available to cows. While green maize stover (harvested after the maize cob reaches physiological maturity) is fed when available, farmers make a special effort to plant several seeds per hill with the aim of thinning the extra plants for livestock feed. On-farm research on smallholder farms has shown that the practice of thinning could increase DM yield by 1.1–2.4 t/ha per season (B.A. Lukuyu, personal communication). As the CP content of thinnings is higher than that of dry maize stover, high-density planting increases the quantity and quality of forage available.

Limitations to dairy production in central Kenya

Good quality napier grass can support milk production of 7–10 kg/cow/d (Anindo and Potter 1986; NDDP 1990) but actual production on farms is only about 5 kg/cow/d (Gitau *et al*. 1994). This poor performance is attributed to an inadequate year-round supply of feed. Napier grass is grown with little or no inorganic or organic fertiliser and DM yields are low. Digestibility of napier grass declines rapidly, along with the nitrogen concentration, as the grass matures, especially during the dry season, reducing milk production. Similarly, utilisation of maize stover, which is the main roughage during the dry season (Said and Wanyoike 1987), is constrained by the low crude protein concentration (Nicholson 1984; Little and Said 1987; Methu 1998).

It is apparent that milk production in central Kenya is limited by both the quantity and quality of feed available. Therefore, any strategies aiming at increasing milk production must address both feed quantity and quality issues. In this regard, herbaceous and multipurpose or shrubby legumes can contribute and are discussed below.

Potential benefits of integrating forage legumes in smallholder fodder systems in central Kenya

The benefits of integrating legumes into fodder systems have been demonstrated. A review by Saka *et al*. (1994) examined the benefits in different farming systems in sub-Saharan Africa. This case study will, therefore, not attempt to review the benefits of forage legumes in animal production systems but will highlight some recent work in Kenya with forage legumes and their contribution to DM yields of fodder crops and animal performance. Experience with the participatory introduction of herbaceous and shrubby legumes into farming systems will be discussed in detail.

Effect of herbaceous legumes on total (grass plus legume) DM production

The DM yield achieved depends on the production system and the legume species used. In cases where nitrogen does not limit grass growth, tropical grasses will always out-yield legumes grown in pure stands; the yield gap may be as high as 10 t/ha (Mwangi 1999). Therefore, in a situation where population pressure is high, as in central Kenya, pure legume plots are not envisaged.

Many workers have reported higher grass DM yields when grown in mixture with legumes (Ibrahim 1994; Mureithi *et al*. 1995; Shehu and Akinola 1995). Nevertheless, research with napier grass-legume mixtures in central Kenya did not give a higher grass yield (Mwangi 1999). Although there was no increase in grass DM yield, when forage legumes were integrated into the forage system, total (grass + legume) DM yield exceeded that of pure napier grass by 20–38% (see Table 2). Mureithi (1992) reported similar findings when napier grass was grown together with *Clitoria ternatea* on the Kenyan coast. The higher DM yield was, therefore, the additive effect of the legume DM rather than its effect on grass performance. This implies that the napier grass-legume mixture was utilising resources (*e.g*. soil, space) more efficiently than pure grass, resulting in a higher forage DM yield.

Effect of herbaceous legumes on animal performance

The potential effect on animal performance of integrating forage legumes into a napier grass mixture is shown in Table 2. Kariuki *et al*. (1998a) supplemented dairy heifers fed on napier grass with *D. intortum* and reported higher liveweight gains than obtained on napier grass alone. As the dairy enterprise in central Kenya is characterised by low liveweight gains in young stock, these results indicate the potential of legumes in the system. Calculations based on these results (Kariuki *et al*. 1998a) and agronomic data collected in Muguga (Mwangi 1999) indicate that integrating legumes into the napier grass fodder system would increase the carrying capacity from 8.2 heifers/ha to 9.8 heifers/ha and total liveweight gain from 1280 kg/ha to 1690 kg/ha/yr (see Table 2).

These cases demonstrate the potential role of forage legumes (herbaceous and shrubby) in livestock systems, not only in Kenya but also throughout sub-Saharan Africa. To date, this potential of forage legumes has not been translated into tangible benefits on smallholder farms, mainly due to poor adoption of forage legume technologies by smallholder farmers.

Table 2. The effect of growing napier grass together with *Desmodium intortum* or *Macrotyloma axillare* on liveweight gain and carrying capacity for dairy heifers.

	Napier grass alone	Napier grass–*D. intortum*	Napier grass–*M. axillare*
DM yield (kg/ha/yr)[1]	20 040	27 780	24 480
DM intake (kg/d)[2]	6.0	7.0	7.0
Actual liveweight gain (kg/d)	0.39	0.42	0.42
Estimated liveweight gain (kg/d)[3]	0.50	0.56	0.51
Carrying capacity (heifers/ha/yr)[4]	9.1	9.8	8.6
Gain (kg/ha/yr)[5]	1295	1690	1530
Advantage (kg liveweight/ha/yr)[6]	–	395	235

[1] Yield in work at Muguga.
[2], [4] and [5] calculations based on napier grass–*D. intortum* mixture (85:15) (Kariuki *et al*. 1998a).
[3] Estimated liveweight gain made using the Allocation of Nitrogen in Organic Resources for Animals and Crops (ANORAC) model (Thorne and Cadisch 1998).
[6] Advantage of mixture over napier grass alone.

Several attempts have been made to introduce herbaceous legumes on smallholder farms in central Kenya. The National Dairy Development Project (NDDP) introduced *Desmodium intortum* and *D. uncinatum* to smallholder farms in central Kenya a decade ago. The project recommended that the legumes be grown and harvested together with napier grass with the aim of improving the nitrogen supply to the dairy cattle (NDDP 1990). More recently, the Kenya Agricultural Research Institute (KARI) introduced both herbaceous and shrubby legumes into the same area. It was intended that the legumes should be intercropped with food crops and planted grasses (Wandera 1995). The Legume Research Network Project (LRNP) also introduced herbaceous legumes mainly as a green manure crop in areas of Embu in central Kenya (LRNP 1999).

Despite these and many other attempts to introduce shrubby and herbaceous legumes on smallholder farms, adoption has been low (Paterson *et al.* 1999). In 1994, NDDP reported that, of 222 farms (with a total of 536 ha) surveyed in eastern Kenya, herbaceous legumes were grown on only 42 farms on a total land area of approximately 7.2 ha. The report did not indicate the proportion of the legume in the dry matter, so the importance of the legume in the system could not be determined.

This case study deals with recent attempts to introduce *D. intortum* cv. Greenleaf through the National Agricultural Research Project Phase II (NARP II) and *Calliandra calothyrsus* through the System-wide Livestock Project (SLP). Factors affecting adoption of the legumes and methods used in an attempt to overcome constraints are discussed.

Experience with Desmodium intortum *cv. Greenleaf*

Napier grass is the main planted forage in central Kenya. Therefore, all attempts to integrate *D. intortum* into farming systems have focused on its role as a companion crop to napier grass. In this work, a participatory approach was used. A survey was conducted in Kandara division of Maragua District, one of the areas in central Kenya where the NDDP introduced *D. intortum* with the objective of identifying constraints to adoption and documenting farmers' experiences with the legume. A total of 33 farmers and 13 key informants (farmers involved with NDDP work) were interviewed. After the survey, on-farm studies were established involving 15 smallholder farmers in the area. The on-farm studies examined the effect on DM yield of growing napier grass with or without legumes. During the studies (over approximately 18 months), dialogue with the farmers was maintained; the experiences shared in this paper are mainly from this period of constant interaction with the farmers.

The farmers identified the major constraints to adoption (Mwangi 1999) as:

- Availability, cost and ease of handling *D. intortum* seed;
- Slow growth during the seedling stage;
- Failure to demonstrate clearly the benefits of herbaceous legumes, especially at the farm level; and
- Poor persistence of the legumes when grown together with napier grass.

To date, the main source of legume seed in Kenya has been the small quantity supplied by researchers conducting on-farm experiments. In contrast to the case for other crops, such as maize, the introduction of forage legumes has not been matched by the supply of seed by commercial seed companies. When available, most seed is imported and expensive. *D. intortum* seed costs approximately US$25/kg. On average, farmers grow 0.2 ha of napier grass (Staal *et al.* 1998). Therefore, to grow *D. intortum* together with napier grass, they would require 400 g of seed (at a seeding rate of 2 kg/ha) at an approximate cost of US$10.00. In an area where monthly income is estimated at US$ 83.3 (Staal *et al.* 1998), cost of seed would represent approximately 12% of farm income for a month. This high cost and the poor availability of seed place the otherwise good technology beyond the reach of poor farmers.

D. intortum seeds are small. Therefore, sowing requires extra care and extra labour at a time (planting season) when the demand for labour for planting food crops is high. Moreover, the tiny seedlings that emerge make weeding difficult. Many farmers with whom we worked indicated that this weeding problem would be a major issue if they were to sow the legume. In several instances, the farmers unintentionally uprooted the legume together with weeds. The incidence of this occurrence was higher where labour was hired.

The study concluded that, if the issues of availability and cost, and difficulty of handling the seed and the seedlings were not addressed, the technology was unlikely to be adopted. An alternative method of establishing the legume through stem cuttings (vines) was envisaged. Establishment from stem cuttings was successful and the survival rate exceeded 90% (Mwangi 1999). Farmers could easily relate to the planting of stem cuttings, as this was similar to the planting of sweet potato vines, which was already common practice.

When farmers learnt that they could establish *D. intortum* from stem cuttings but that the supply of stems from the research team was limited, they established small nurseries. The nurseries were mainly near shallow wells on the farm or under banana plants where water and shade were available. Eventually, these nurseries became sources of planting material, thus ending the dependency on the research team for supply of stems. Farmers used the materials from the nurseries to experiment with the legume. When the experiments started, the only niche for the legume that was discussed with the farmers was the napier grass stands. Farmers later planted the legume under coffee, banana and avocado trees and on soil conservation structures. This planting and experimentation by farmers would not have been possible if the legume had to be established from seed. Planting stem cuttings made weeding the stands easier. Therefore, solving the propagation issue and putting the solution into farmers' hands increased the potential for adoption of the *D. intortum* technology. Notably, difficulties with propagation are critical constraints to fodder adoption. Accordingly, the widespread adoption of napier grass is mainly attributed to the ease with which it can be propagated (Mwangi *et al.* 1995)

Anecdotal information has indicated that farmers, who were not involved in the study, later received planting material from farmers with nurseries; furthermore, these new farmers went on to establish their own nurseries. The effectiveness of the nurseries as a source of *D. intortum* planting material will be assessed through a planned adoption study.

Initial slow growth of D. intortum. As stated previously, the main constraint to animal performance in central Kenya is the inadequate year-round supply of good quality forage. Therefore, any forage introduced to the area must be fast-growing and high-yielding. This explains the adoption of napier grass by the majority of smallholder dairy farmers (Mwangi *et al*. 1995; Staal *et al.* 1998) and its likely use as the model to assess other forage crops.

The initial growth of *D. intortum* is slow, especially when established from seed; moreover, it cannot be compared with napier grass even when stem cuttings are used. When napier grass is established from rooted splits, the farmers can take the first cut about 3–5 months after planting, depending on rainfall; in contrast, *D. intortum* takes 8–9 months before a cut can be taken. During this period, napier grass will have produced 7.7 t /ha DM compared with only 3.7 t/ha DM from the legume (Mwangi 1999).

As the legume was relatively new to the farmers, the initial slow growth rate persuaded them that the potential was low and that the legume was a waste of time and resources. The main question asked by the farmers at this stage was: 'Will the legume ever get to a stage where we can harvest and have substantial amounts to feed the cow?' At this point, adoption of the forage would have been abandoned if the farmers had not been given positive proof of its longer-term benefits. Therefore, a decision was made to take the farmers to the research centre where they could see an already established napier grass–*D. intortum* mixture. Initially, the farmers could not relate the established legume to the struggling seedlings on their farms. The visit had a major impact on farmers' perception of the technology. Nevertheless, as trips to the research centre might be costly and do not always reflect conditions on smallholder farms, the research team emphasised farmer-to-farmer visits to enhance adoption of the legume technology. During these visits, the farmers saw the potential of the legume and always carried planting material back to their farms. Plans are underway to conduct an adoption study to determine how effective this approach has been, but anecdotal information indicates it has been successful.

Failure to demonstrate clearly the benefits of herbaceous legumes, especially at the farm level. If farmers have to adopt a technology, they must be able to see the benefits clearly. Sometimes, beneficial technologies are rejected because the benefits cannot be clearly demonstrated or are long-term. The major benefits of forage legumes include higher DM yields (Keya *et al.* 1971; Keya and Kalangi 1973; Reategui *et al*. 1995; Shehu and Akinola 1995; Mwangi 1999); biological nitrogen fixation (BNF) (Cadisch *et al*. 1989; Thomas and Sumberg 1995; Mwangi 1999); improved soil fertility and better animal performance due to the improved N supply in the diet (Kariuki *et al*. 1998a;1999). Some of these benefits are difficult to demonstrate on-farm and others, such as improvements in soil fertility, are long-term benefits.

When the research team introduced *D. intortum* to farmers in central Kenya, higher DM yield, higher N concentration and BNF were the benefits emphasised. These were the benefits observed in on-station work (Mwangi 1999). A further benefit observed on-station but not emphasised in discussions with farmers was weed suppression by the legume when grown together with napier grass. Interestingly, this turned out to be the most important benefit to the farmers, as it could be observed and quantified easily.

Napier grass is usually cut after 4–8 weeks of regrowth and after each cut the plot should be weeded. Therefore, with a minimum of 4 cuts/year the plot has to be weeded 4 times. It takes 8 man-days to weed 1 ha of napier grass. At the current rate of US$1.9/d, it would cost at least US$60/year to weed a hectare of napier grass. Therefore, the savings offered by the weed-suppressing effect of *D. intortum* were attractive to farmers and were the main benefit they saw in the legume technology. Although the farmers had not realised the effect of the technology on livestock performance, which the research team emphasised, they were ready to adopt the technology because of other benefits such as weed control.

Poor persistence of the legume when grown together with napier grass. A major constraint cited by farmers was the poor persistence of *D. intortum* when grown together with napier grass. One farm had a substantial amount of *D. intortum* growing in a pure stand but apart from this, there was no trace of the legume in the napier grass plots. It was suspected that napier grass, a very competitive grass, had edged out the legume through competition. This apparent lack of persistence could have been caused by one of several factors:

- The management (*i.e.*, spacing, harvesting frequency, manure application *etc*.) of napier grass was not adjusted to accommodate the legume in the intercrop.
- The legume was planted in the same row with napier grass, tending to maximise between-species competition.
- The legume seed was drilled into an established stand of napier grass; therefore, the young seedlings had little chance of surviving.

Experience with Calliandra calothyrsus *in central Kenya*

Since the 1980s, *C. calothyrsus* has been considered to be a potentially important N-rich supplement for increased milk production. The focus has been on integrating calliandra into the existing cropping system on smallholder farms. In this regard, several niches have been identified where calliandra can be grown (Paterson *et al*. 1999).

Niches where calliandra has been planted:

- Hedges around the farm compound;
- Along contours and soil conservation terraces;
- Intercropped with napier grass; and
- Between upper-storey trees (mainly under *Grevillea robusta*).

As with the herbaceous legume, the benefits of growing *C. calothyrsus* in different niches have been demonstrated clearly in research experiments. Although, in the rainy season, DM yield of napier grass was not affected by intercropping it with *C. calothyrsus* (NAFRP 1993), in the dry season DM yield was increased (Nyaata 1998). Feeding trials have considered *C. calothyrsus* as a supplement to the basal napier grass diet and as a substitute for dairy meal (Paterson *et al.* 1999). Supplementing milking animals with 1 kg/d of fresh *C. calothyrsus* increased milk yield from 10 kg/cow to 10.75 kg/cow/d (Paterson *et al*. 1999). Despite these benefits, adoption of *C. calothyrsus* by smallholder farmers has been poor. Farm survey reports attributed poor adoption of *C. calothyrsus* to lack of seed/seedlings but personal observation and discussion with farmers indicate that objectives of introducing the trees were not discussed sufficiently with farmers.

Lack of planting material. Although fodder trees are currently gaining popularity in smallholder farming systems, most of the seed has come from international research centres (*e.g.* ICRAF), NGOs and localised harvests in western Kenya and Embu (Franzel *et al.* 1999; Wambugu *et al*. 2001). The short supply of seed has constrained the adoption of calliandra by smallholders (Gerrits 2000). Farmers rarely collect or use seed from their own or neighbours' farms, as they still expect free seedlings or seed from projects, NGOs and international centres (Franzel *et al.* 1999). Current efforts aim to overcome this constraint by training and encouraging farmers and farmer groups to produce and use their own seed (Gerrits 2000; C. Wambugu, unpublished data). Unlike the case of *D. intortum*, vegetative propagation of *C. calothyrsus* is not an option. Therefore, the way forward is for farmers (in groups or as individuals) to produce seed from seed orchards or from a number of trees that are not coppiced so that they can produce seed.

Lack of clear objectives. A farmer needs 500 calliandra trees to feed a cow throughout the year at a rate of 2 kg/d DM (Paterson *et al*. 1996; 1999); however, farmers often have fewer than 100 trees. In the Embu area, considered to have the highest rate of adoption in Kenya, only one of 45 farmers sampled claimed to have enough calliandra trees to feed his cows throughout the year. Currently, it is common to find farmers with fewer than 10 calliandra trees. Therefore, the amount of calliandra fodder available to feed to livestock is small.

The major introduction of multi-purpose trees in many of the dairy areas of Kenya was spearheaded by the NDDP; however, it seems that the number of trees required to feed a cow effectively and management of the trees to maximise biomass production were not discussed (authors, personal observation). On farms where the NDDP operated, it is common to find only 2 or 3 tall trees with no effort to expand the number planted or manage the trees to form a hedge. Dairy farmers in central Kenya need to expand the number of calliandra trees to the recommended 500 trees/cow or to adopt appropriate feeding practices that make best use of the limited quantity of calliandra fodder available.

Current approach for the introduction of forage legumes in central Kenya

Participatory forage technology development

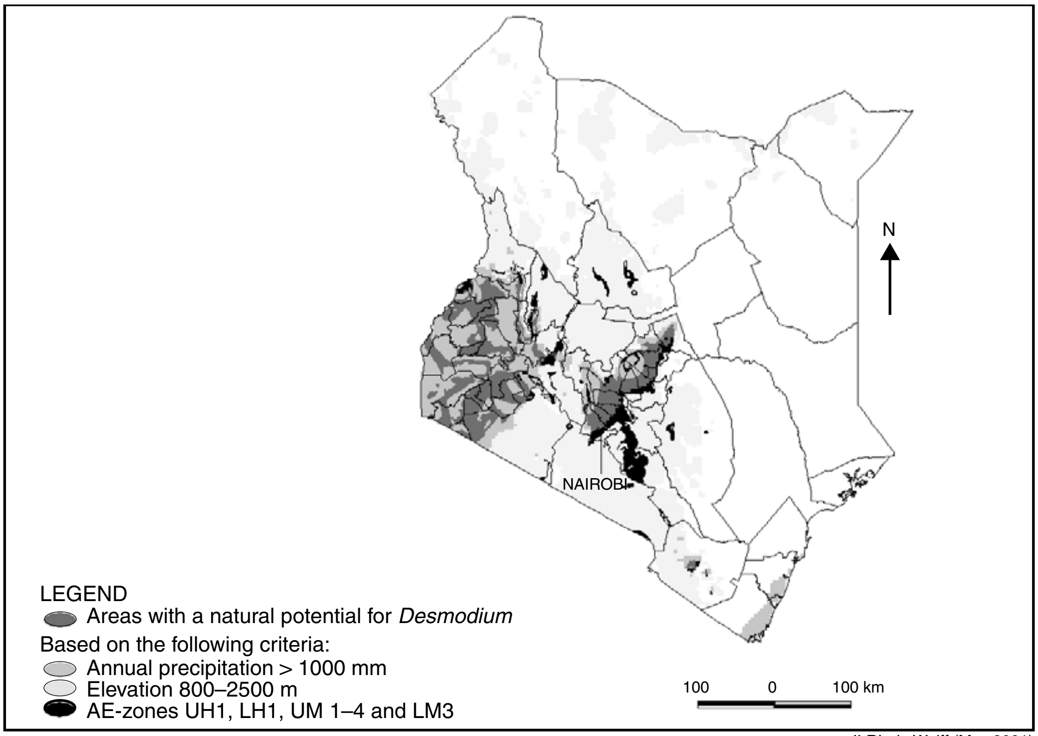
The aim of participatory forage technology development is to involve farmers in the evaluation of legume species that will fit into their production systems. In the past, researchers, working on-station and using biomass production in small plots, selected legumes and then passed these on for dissemination. This approach assumes that the farmer is interested only in biomass production. However, other attributes of the legume might be more important to the farmer, *e.g.* weed control. Secondly, the legume might not perform when put into the farmer's farming system where it might be grown together with grasses or food crops. A participatory approach gives the farmers a choice in what legumes to grow; at present, it is either *D. intortum* or *C. calothyrsus*.

Targetting of the technology

GIS tools were used to target the legume technologies. The first step in this targetting used biophysical conditions (*i.e*., altitude, rainfall and agro-ecological zones) to determine areas where *D. intortum* and *C. calothyrsus* can be grown (Figures 1a; 1b). The numbers of households in the natural potential domains for *D. intortum* and *C. calothyrsus* are about 310 000 and 355 000, respectively. The second step used market access for milk as determined by road infrastructure, and human and dairy cattle densities. Human and dairy cattle population densities were used as an indicator of intensification and hence the type of production system used (*e.g.* mainly zero-grazing when the densities were high). Intensification is a prerequisite to planting forages and increases the chances that a farmer will adopt planted forages including leguminous forage materials. This second step reduced the recommendation domain to parts of central and western Kenya (Figures 2a; 2b). Scaling-up efforts are currently utilising information developed through the GIS to target areas where the technology is being validated with farmers.

Putting the germplasm into farmers' hands

One of the lessons learnt from this work is that germplasm availability and cost can curtail the adoption of an otherwise excellent technology. In both cases presented here, availability of planting material and ease of propagation were critical issues that needed to be addressed before farmers would adopt the technologies. Giving farmers free seedlings or seed from international research centres, research projects and NGOs can stifle



ILRI, de Wolff (May 2001)

Figure 1a. Biophysical potential of *Desmodium intortum.*

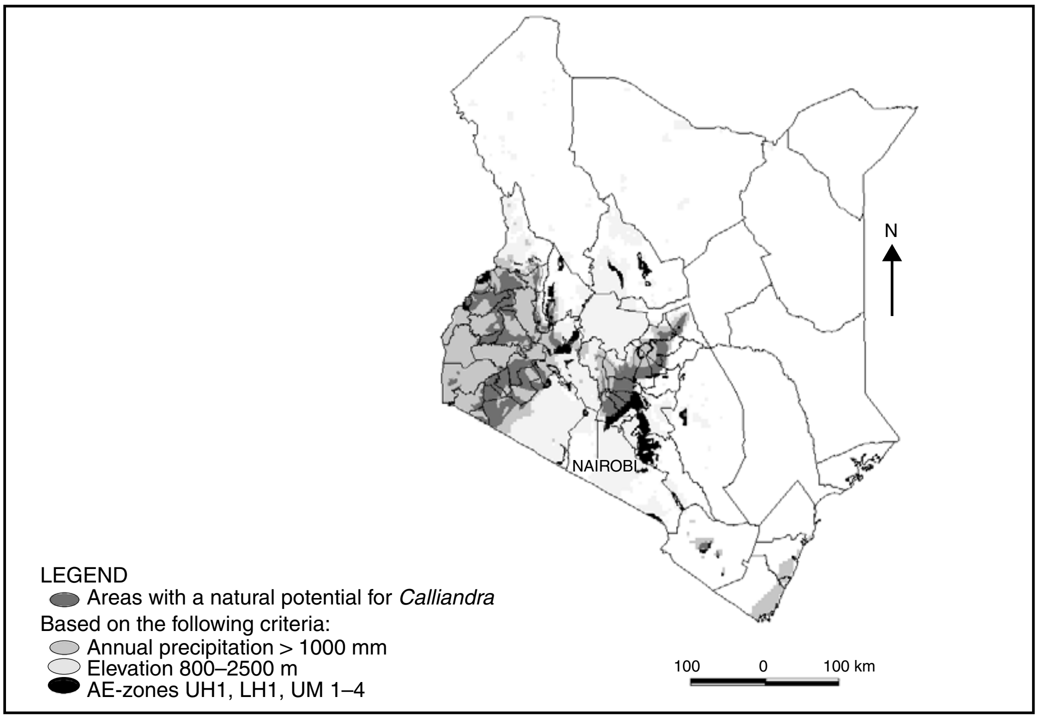


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Figure 1b. Biophysical potential of *Calliandra calothyrsus.*

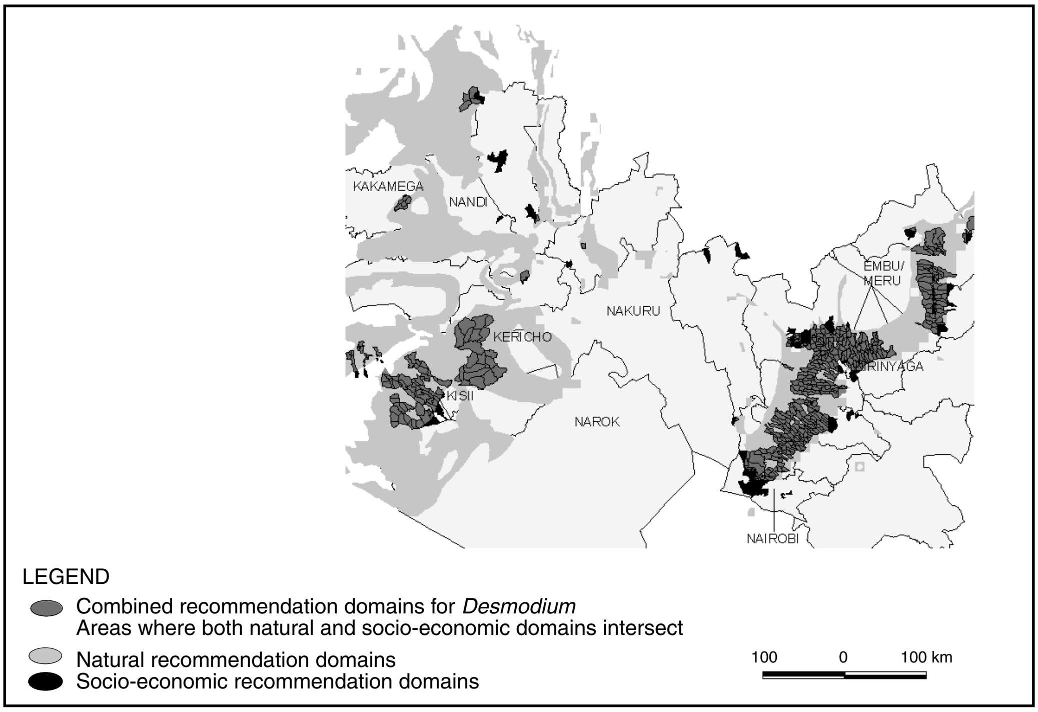

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Figure 2a. Biophysical and socio-economic potential of *Desmodium intortum.*

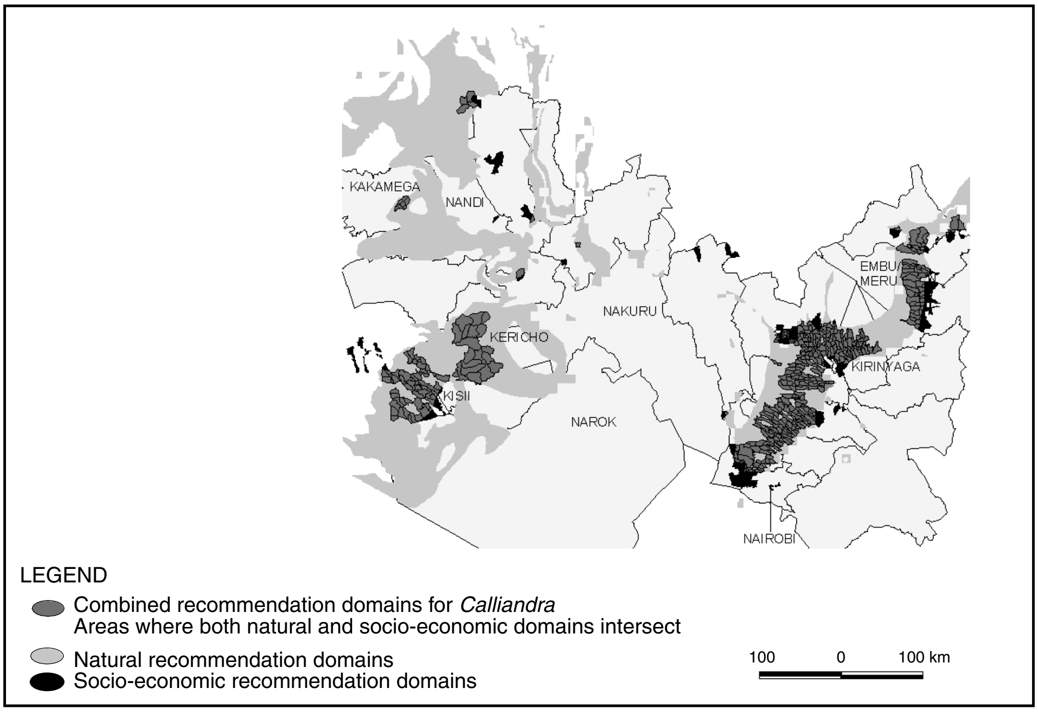

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Figure 2b. Biophysical and socio-economic potential of *Calliandra calothyrsus.*

farmers' initiatives to use on-farm resources because they expect to continue to be given planting material. This was and might still be the case with *D. intortum* and *C. calothyrsus* in central Kenya. Conversely, it is futile to introduce the technology without making some planting material available. Therefore, the aim should be to move farmers forward from a point where they are dependent on research institutions and NGOs to where they can handle the technology with little or no intervention from outside their own systems. Consequently, it is wise to address the problems of germplasm availability and propagation early in the phase of forage technology development, otherwise adoption will be poor.

Currently SDP and SLP are forging partnerships with other stakeholders who are interested in promoting forage technologies. These stakeholders include apex farmers' organisations [the Dairy Goat Association of Kenya (DGAK), Meru District Dairy Goat Association, dairy cooperatives, *etc*.], NGOs, community-based organisations (*e.g*. church groups) and the Departments of Agriculture and Livestock Production in the Ministry of Agriculture and Rural Development (MoARD). Through these stakeholders, SDP and SLP aim to create awareness and build capacity on the handling of the legume technologies within the society. The emphasis has included training on propagation, management and utilisation of the legumes through demonstrations, farmer exchange visits and group training. The aim has been to ensure that extension agents and farmers acquire the skills and knowledge necessary to handle the legumes with ease.

Through these stakeholders, target farmer groups were identified. Planting material (calliandra seed and desmodium cuttings) was supplied and group nurseries were established. Calliandra seedlings from these nurseries were distributed to members of the groups for planting. Currently, a few farmers have more than 500 trees on their farms. Some are already producing seed and the next step is to make seed production a commercial activity that will drive the expansion in terms of the number of trees on farms and number of farmers and farmer groups involved. The DGAK is taking this further using the 'Goat in Trust' model to distribute seed to its members. In this new initiative, members will receive seed from the association on condition that they will return a similar quantity of seed plus a small 'interest' to the association. This seed will then be passed on to the next farmer or group with the same conditions, effectively developing a community-based seed scheme.

Desmodium cuttings have been supplied to 19 farmer groups with close to 500 members. These groups are a subset of the groups working with calliandra and desmodium is seen as an additional forage legume. Cuttings were supplied to some of these groups in November 2000 and group/individual farmer nurseries were established. By May 2001, approximately 28 500 cuttings from these nurseries had been established on farms. An estimated 90% of the cuttings took, meaning that, in one season, about 25 000 cuttings were planted in farmers' fields. In contrast to the situation for calliandra, these nurseries are fairly permanent and will supply more cuttings to farmers in the future. The SDP/SLP team is monitoring the management of the nurseries and the number of cuttings that can be produced.

Adoption of any technology is enhanced when farmers can easily see the benefits. Therefore, short-term benefits should be emphasised and the long-term ones should also be mentioned. Visits to research centres or to other farmers will help farmers visualise the potential of the technology. Currently, the SDP is planning to start participatory legume technology development in central Kenya. At present, only *D. intortum* is being introduced to farmers. This gives the farmers little choice on what they can grow. In the planned work, farmers will be involved in the evaluation and selection of herbaceous legumes through mother-baby trial set-ups. 'Best bet' herbaceous legumes will be grown in mother trials in the target areas. The farmers will be encouraged to select from this large number of legumes, the types that they think will fit into their production systems; they will then evaluate the legumes on their own farms. It is hoped that this process will lead to the adoption of herbaceous legumes in central Kenya.

Conclusion

Participatory forage legume technology development and evaluation may be the key to improving adoption of forage legumes amongst smallholder farmers in central Kenya. In order to enhance farmer participation, the mother-baby trial approach will be used in evaluation and selection of forage legumes.

Working with farmer groups may enhance adoption of the legume technologies as the farmers can share experiences and cost of inputs required for the technologies to succeed. Hopefully, this group approach will enhance wider adoption of the technologies even if the most proactive farmers may be upset because they feel they are making effort for the weaker farmers who gain benefits they feel should remain with them. Compared with an individual farmer approach, the group approach is also more cost-effective as many farmers can be reached at a time. Moreover, the group approach may be more sustainable as the farmer groups (*i.e.*, co-operatives) will be sources of information on the technologies long after the project has withdrawn from the area.

Germplasm should be evaluated in the system where the forage will be grown. At present, forage legumes are evaluated in small plots and in pure stands although farmers may grow them together with companion grasses. In the current method of evaluation, DM yield is the main factor considered while the ability to fit into a system (*e.g.* intercropping) might be a more appropriate issue to consider. Participatory forage technology development will help to address these issues. The participatory approach may be expensive and time-consuming but in the long run it is hoped that the benefits will outweigh the costs.

References

ANINDO, D.O. and POTTER, H.L. (1986) Milk production from Napier grass (*Pennisetum purpureum*) in a zero-grazing feeding system. *East African Agricultural and Forestry Journal,* **52**, 106–111.

BAYER, W. (1990) Napier grass – a promising fodder for smallholder livestock production in the tropics. *Plant Research and Development,* **31**, 103–111.

CADISCH, G., SYLVESTER-BRADLEY, R. and NOSBERGER, J. (1989) ^{15}N-based estimation of nitrogen fixation by eight tropical forage-legumes at two levels of P:K supply. *Field Crops Research,* **22**, 181–194.

CBS (Central Bureau for Statistics) (1994) *Kenya population census 1989. Vol. I.* (Office of the Vice-President and Ministry of Planning and National Development: Nairobi, Kenya). 197 pp.

DANIDA (Danish International Development Agency)/MoLD (Ministry of Livestock Development) (1991) *Kenya dairy master plan. Study report. DANIDA and MoLD, Nairobi, Kenya.* 289 pp.

FRANZEL, S., ARIMI, H., MURITHI, F. and KARANJA, J. (1999) *Calliandra calothyrsus*: assessing the early stages of adoption of a fodder tree in the highlands of central Kenya*. AFRENA Report No. 127. International Center for Research in Agroforestry, Agroforestry Research Network for Africa (AFRENA), Nairobi, Kenya*. 19 pp.

GERRITS, A. (2000) Dissemination of fodder materials in the central highlands of Kenya. In: Franzel, S. (ed.) Calliandra calothyrsus *and other fodder trees: moving forward in research and development*. pp. 12–14. [Oxford Forestry Institute and International Centre for Research in Agroforestry (ICRAF): Nairobi, Kenya].

GITAU, G.K., O'CALLAGHAN, C.J., MCDERMOTT, J.J., OMORE, A.O., ODIMA, P.A., MULEI, C.M. and KILUNGO, J.K. (1994) Description of smallholder dairy farms in Kiambu district, Kenya. *Preventative Veterinary Medicine,* **21**, 155–166.

IBRAHIM, M.A. (1994) *Compatibility, persistence and productivity of grass-legume mixtures for sustainable animal production in the Atlantic zone of Costa Rica*. Ph.D. Dissertation. Wageningen Agricultural University, Wageningen, Netherlands. 129 pp.

KARIUKI, J.N., BOER, H., TAMMINGA, S., GITAU, G.K., GACHUIRI, C.K. and MUIA, J.M. (1998a) Rumen degradation and intestinal digestion of protein in Napier grass and other Kenyan forages. *Animal Feed Science and Technology,* **31**, 160-169.

KARIUKI, J.N., TAMMINGA, S., GACHUIRI, C.K., GITAU, G.K. and MUIA, J.M.K. (1998b) Intake, DM degradation and rumen fermentation as affected by varying levels of desmodium and sweet potato vines in Napier grass fed to cattle. *Animal Feed Science and Technology,* **31,** 151-159.

KARIUKI, J.N., GITAU, G.K., GACHUIRI, C.K., TAMMINGA, S. and MUIA, J.M.K. (1999) Effect of supplementing Napier grass with desmodium and lucerne on DM, CP and NDF intake and weight gains in dairy heifers. *Livestock Production Science,* **60**, 81–88.

KEYA, N.C.O. and KALANGI, D.W. (1973) The seeding and superphosphate rates for the establishment of *Desmodium uncinatum* (Jacq) DC by oversowing in uncultivated grasslands of western Kenya. *Tropical Grasslands,* **7**, 319–325.

KEYA, N.C.O., OLSEN, F.J. and HOLLIDAY, R. (1971) The role of superphosphate in the establishment of oversown tropical legumes in natural grasslands of western Kenya. *Tropical Grasslands,* **5**, 109–116.

LITTLE, D.A. and SAID, A.N. (eds) (1987) *Utilisation of agricultural by-products as animal feeds in Africa. Proceedings of a workshop by the African Research Network for Agricultural By-products (ARNAB) held at Blantyre, Malawi in September 1986*. [ILCA (International Livestock Centre for Africa): Addis Ababa, Ethiopia]. 179 pp.

MBOGOH, S.G. (1984) *Dairy development and internal marketing in sub-Saharan Africa: some preliminary indicators of policy impacts*. [ILCA (International Livestock Centre for Africa): Addis Ababa, Ethiopia]. 34 pp.

METHU, J.N. (1998) *Strategies for utilisation of maize stover and thinnings as dry season feed for dairy cows in Kenya*. Ph.D. Thesis. University of Reading, Reading, UK. 298 pp.

METHU, J.N., OWEN, E., ABATE, A., MWANGI, D.M. and TANNER, J. (1996) Smallholder dairying in central Kenya highlands: practices in the utilization of maize stover as a feed resource. In: Agronam Services Ltd (ed.) *Focus on Agricultural Research for Sustainable Development in a Changing Economic Environment. Proceedings of the 5th Kenya Agricultural Research Institute (KARI) Scientific Conference*. pp. 243-251. (KARI: Nairobi, Kenya).

MoA (Ministry of Agriculture) (1987) Fertiliser use recommendation project; description of the first priority sites in the various districts (Murang'a district*). Report no. 21. MoA, National Agricultural Laboratories, Nairobi, Kenya.* 22 pp.

MoLD (Ministry of Livestock Development) (1985) *Annual Report, Ministry of Livestock Development, Nairobi, Kenya*. 167 pp.

MUREITHI, J.G. (1992) *Alley cropping with leucaena for food and fodder production in smallholder farms in lowland coastal Kenya*. Ph.D. Thesis. University of Reading, Reading, UK. 173 pp.

MUREITHI, J.G. (ed.) (1999) *Legume Research Network Project Newsletter No 1, 1999*. (Kenya Agricultural Research Institute: Nairobi, Kenya). 24 pp.

MUREITHI, J.G., TAYLER, R.S. and THORPE, W. (1995) Productivity of alley farming with leucaena (*Leucaena leucocephala* Lam.de Wit) and Napier grass (*Pennisetum purpureum* K. Schum) in coastal lowland Kenya. *Agroforestry Systems,* **31**, 59–78.

MWANGI, D.M. (1999) *Integration of herbaceous legumes into Napier grass fodder systems in central Kenya: constraints and potential.* Ph.D. Thesis. University of London, London, UK. 272 pp.

MWANGI, D.M., THORPE, W., METHU, J.N., MULLINS, G., CHUI, J.N., MUSEMBI, F.K., LUKUYU, M., CHEGE, L., MUTUOTA, J. and ODONGO, N.E. (1995) *Factors affecting the adoption of planted forages in the Nairobi milk shed: report on participatory rural appraisals conducted in Kiambu, Kenya.* [KARI (Kenya Agricultural Research Institute): Nairobi and NARC (National Agricultural Research Centre): Muguga, Kenya]. 35 pp.

NAFRP (National Agroforestry Research Project) (1993) National Agroforestry Research Project. KARI Regional Research Centre, Embu. *AFRENA Report No. 69. AFRENA (Agroforestry Research Network for Africa), Nairobi, Kenya.* 120 pp.

NDDP (National Dairy Development Project) (1990) *Dairy report: National Dairy Development Project. NDDP, Naivasha, Kenya*. 79 pp.

NICHOLSON, J.W.G. (1984) Digestibility, nutritive value and feed intake. In: Sundtol, F. and Owen, E. (eds) *Straw and fibrous by-products as feed*. pp. 340-372. (Elsevier: Amsterdam, Netherlands).

NYAATA, O.Z. (1998) *Management of* Calliandra calothyrsus *in association with* Pennisetum purpureum *for increased dry season forage production on smallholder dairy farms in central Kenya*. Ph.D. Thesis. University of Reading, Reading, UK. 206 pp.

OMORE, A., MURIUKI, H., KENYANJUI, M., OWANGO, M. and STAAL, S. (1999) *The Kenya dairy sub-sector. A rapid appraisal*. (MoA/KARI/ILRI: Nairobi, Kenya). 51 pp.

PATERSON, R.T., ROOTHAERT, R., NYAATA, O.Z., AKYEAMPONG, E. and HOVE, L. (1996) Experience with *Calliandra calothyrsus* as a feed for livestock in Africa. In: Evans, D.O. (ed.) *Proceedings of an international workshop on the genus* Calliandra. pp. 195-209. (Winrock International: Bogor, Indonesia).

PATERSON, R.T., KIRUIRO, E. and ARIMI, H.K. (1999) *Calliandra calothyrsus* as a supplement for milk production in the Kenyan highlands. *Tropical Animal Health and Production,* **31**, 115-126.

POTTER, H.L. (1987) Inventory of feed resources for the smallholder farmer in Kenya. In: Kategile, J.A., Said, A.N. and Dzowela, B.H. (eds) *Animal Feed Resources for Small-scale Livestock Producers. Proceedings of the 2nd Pasture Network for Eastern and Southern Africa (PANESA) workshop, Nairobi, Kenya, 11-15 November 1985.* pp. 2-22. [International Development Research Centre (IDRC): Nairobi, Kenya].

REATEGUI, K., VERA, R.R., LOKER, W.L. and VASQUEZ, M. (1995) On farm grass-legume pasture performance in the Peruvian rainforest. *Experimental Agriculture,* **3**, 1227–1239.

SAID, A.N. and WANYOIKE, M.M. (1987) The prospect of utilizing urea treated maize stover by smallholders in Kenya. In: Little, D.A. and Said, A.N. (eds) *Utilization of Agricultural By-products in Africa. ARNAB (African Research Network for Agricultural by-products) and ILCA (International Livestock Centre for Africa) workshop held at Blantrye, Malawi, September 1986.* pp. 15-26. (International Livestock Centre for Africa: Addis Ababa, Ethiopia).

SAKA, A.R., HAQUE, I., LUPWAYI, N.Z. and EL-WAKEEL, A. (1994) *Forage legumes in crop-livestock systems of sub-Saharan Africa. Issue 24. ILCA (International Livestock Centre for Africa) Environmental Science Working Document. ILCA, Addis Ababa, Ethiopia.* 82 pp.

SHEHU, Y. and AKINOLA, J.O. (1995) The productivity of pure and mixed grass-legume pastures in the Northern Guinea Savanna zone of Nigeria. *Tropical Grasslands,* **29**, 115–121.

STAAL, S., CHEGE, L., KENYANJUI, M., KIMARI, A., LUKUYU, B., NJUBI, D., OWANGO, M., TANNER, J., THORPE, W. and WAMBUGU, M. (1998) A cross-sectional survey of Kiambu district for the identification of target groups of smallholder dairy producers. *KARI (Kenya Agricultural Research Institute)/ILRI (International Livestock Research Institute) Collaborative Project Research Project Report, Nairobi, Kenya.* 73 pp.

STOTZ, D. (1983) *Production techniques and economics of smallholder livestock production systems in Kenya. Farm management handbook of Kenya*. [MoLD (Ministry of Livestock Development): Nairobi, Kenya]. 140 pp.

THOMAS, D. and SUMBERG, J.E. (1995) A review of the evaluation and use of tropical forage legumes in sub-Saharan Africa. *Agriculture, Ecosystems and Environment,* **54**, 151–163.

THORNE, P.J. and CADISCH, G. (1998) *ANORAC (computer programme). Allocation of nitrogen in organic resources for animals and crops*. [NRI (Natural Resources Institute): Chatham, UK].

WAMBUGU, C., FRANZEL, S., TUWEI, P. and KARANJA, G. (2001) Scaling up the use of fodder shrubs in central Kenya. *Development in Practice*, **11**, 487-494.

WANDERA, J.L. (1995) *Pasture/Fodder Research Program*. [KARI (Kenya Agricultural Research Institute): Nairobi and NARC (National Agricultural Research Centre), Kitale, Kenya]. 48 pp.