NATIONAL AGROFORESTRY RESEARCH PROJECT

KARI/KEFRI/ICRAF

PROCEEDINGS of the END-of-PROJECT WORKSHOP

for the

**ODA-Funded Project Number R5732 (Forestry Research Programme)
With additional funding from R5999 (Livestock Production Programme)
and R6001 (Agronomy and Cropping Systems)**

Development and On-farm Evaluation of Agroforestry Livestock Feeding Systems

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NATIONAL AGROFORESTRY RESEARCH PROJECT

Animal Nutrition End-of-Project Workshop

Izaac Walton Inn, Embu, Kenya. 30 July 1996

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Introduction

The workshop was held on 30 July, 1996 at Izaak Walton Inn, Embu. During the workshop, the principal activities of the project were reviewed and the results highlighted. The attendance comprised of about 74 participants drawn from Kenya Agricultural Research Institute (KARI, staff from Nairobi Headquarters, National Agricultural Research Centre, Muguga, and Regional Research Centre, Embu); Ministry of Agriculture, Livestock Development and Marketing (MoALDM, from Agriculture, Livestock Development, and Veterinary Departments); and from Ministry of Environment and Natural Resources (MoENR, from the Forest Department) in the mandate districts of the Embu Regional Research Centre, viz. Embu, Mbeere, Kirinyaga, Nyeri, Murang'a, Tharaka-Nithi, Meru, and Nyambene.

Welcome (Mr. S. P. Gachanja, Director, KARI Regional Research Centre, Embu)

The Centre Director welcomed all those present and self-introductions were made. He then gave an overview of the centre's research activities and highlighted some major achievements. He emphasized the need for strong Research/Extension/Farmer linkages so that the technologies developed would be for the benefit of the farming community. Poor animal nutrition is one of the factors causing a decline in animal production in the mandate area.

The KARI/NRI Livestock Feeding Systems Project was started about 30 months ago to try and resolve some of the animal nutrition problems. He indicated that the purpose of the meeting was for the scientists working within the project to present the data that had been generated so far. The role of the participants in the workshop was to critically analyze the data and suggest ways of improvement in the next phase of the project.

Official Opening (Dr. A. N. Abate, Assistant Director, Animal Production, KARI Headquarters)

Dr. Abate asked the participants to assess whether the outputs of the project were in line with the objectives set when the project was initiated in 1994. There was also need to look at the impact of project activities. Assessment of impact need not wait for, for example 10 years after project conclusion, but could be assessed during project implementation.

She noted that Research and Development is a process that takes place both on-station and on-farm and this would be clearly evident during the presentation of results from this project.

There was need to assess whether the technologies developed are sustainable. Areas needing special attention included, potential for adoption of the technologies, rate of adoption, and extent of adoption.

Finally, there was need to have an overall assessment of the project. Do we need a phase two of the project? If necessary, what omissions in phase I need to be included in phase II?

Overview of the KARI/KEFRI/ICRAF National Agroforestry Research Project (Mr. G. M. Karanja, KARI Project Manager, Regional Research Centre, Embu)

The areas highlighted in the presentation were characteristics of the project area; viz. biophysical features, socio-economic characteristics, crop production, livestock production, and tree production.

The major constraints identified in the project area, that is, the coffee-based land use systems were highlighted and the objectives of the project were noted. Some individual research activities were also mentioned. Lastly, the constraints facing the project were described.

Main Objectives of the Livestock Feeding Systems Project (Mr. Ralph Roothaert, Associate Expert, ICRAF, Regional Research Centre, Embu)

Development of technologies to alleviate fodder shortage, both quantity and quality especially during the dry season, through on-station and on-farm research of exotic and indigenous fodder trees.

At the conclusion of the official opening session, the workshop proceeded to the technical and plenary sessions. These were presided over by the following officers:

Chairman:	Dr. Macharia Gethi (Deputy Director, KARI Regional Research Centre, Embu)
Rapporteurs:	(District Veterinary Officer, Tharaka-Nithi district and District Livestock Production Officer, Mbeere district)

These proceedings are divided into three parts. The first part contains three papers which together provide background information regarding the steps leading to the initiation of the agroforestry livestock feeding systems project, including the start-up workshop and the workplan which emerged from these discussions. It also contains a brief note of the major limitations which were experienced during the execution of the project.

The second part of the proceedings consists of six technical papers which were presented during the course of the workshop, together with a summary of the questions and answers which followed each presentation.

The final section of the proceedings is a record of the plenary discussion session which followed the formal presentations. During this session, the achievements of the project were considered in the light of the objectives set at the time of project initiation and the need for a follow-up, second phase of the work was debated.

Part I

Background Information

Paper 1

NATIONAL AGROFORESTRY RESEARCH PROJECT

Summary of Animal Nutrition Start-up Workshop

On 16 and 17 June 1994, the ODA-funded Animal Nutrition programme of the National Agroforestry Research Project (NAFRP) held a start-up workshop at the Embu Agricultural Staff Training College (EAST). The objectives of the event were to publicize the existence of the new programme and to elicit the opinions of the participants regarding the proposed work programme for the period of the current funding agreement (until March 1996, subsequently extended to July 1996).

The invitees included Provincial Directors of Agriculture, Livestock Production and Forestry from Eastern (Embu) and Central (Nyeri) Provinces, together with District Agricultural, Livestock Production (dairy) and Forestry Officers from the highlands areas of Central Kenya, based in Kiambu, Nyeri, Murang'a, Kirinyaga, Tharaka-Nithi, Meru, Nyambene and Embu. Representatives of non-governmental organizations based in Embu, including Plan International, the Catholic Diocese, the Methodist Church and the Church of the Province of Kenya (CPK) were also invited. A total of 27 official invitees attended the workshop, representing all parts of the mandate area of NAFRP in the Embu District. These were supported by 13 members of staff of NAFRP and administrators from the KARI Regional Research Centre.

16 June 1994

1. The official opening of the workshop and the welcome to the delegates was given by the Director of the KARI station at Embu, Mr S. P. Gachanja. He gave an over-view of the activities of the station and initiated the deliberations.

2. The Project Manager, Mr F. Murithi, (KARI) followed the opening address with an over-view of the activities of NAFRP. He noted that work to date had provided information on the agronomic characteristics of fodder trees but had not generated data on the actual levels of animal production that could be obtained from the trees under the conditions to be found in the East African highlands.

3. The proposed animal production programme was introduced in three parts. Firstly, Mr E.M. Kiruiru (KARI) emphasized the animal production activities at KARI which fall outside of the scope of NAFRP. Mr R.L. Roothaert (ICRAF) then noted the donors who are providing funding and material assistance to the project (KARI, KEFRI, ICRAF, SIDA and the governments of Holland and UK) and outlined the surveys and participatory research which had been taken into account in the design of the work programme. Finally, Dr R.T. Paterson (ICRAF) described the proposed programme of activities.

4. After lunch, the participants were divided into four groups, each of which visited a typical target farm in the high-potential part of the Embu region.

5. An informal reception was held in the evening upon return from the field, with a view to stimulating informal discussions amongst the delegates.

17 June 1994

6. A brief visit was made to the agroforestry site at the KARI station to view on-going research activities in fodder production; alley-cropping with maize and beans; and erosion control, together with the site for bulk production of tree fodder for use in future feeding experiments. Species planted include two varieties of *Morus alba, Manihot glaziovii, Calliandra calothyrsus* and *Leucaena diversifolia.*

7. In accordance with the main work proposals which had been presented under section 3 above, delegates were divided randomly into three groups, one group to discuss each of the following topics:

- on-farm research
- on-station research
- dryland research

The group discussions were followed by a plenary session in which each group presented the conclusions of it's deliberations. There was opportunity for comment from the floor regarding the opinions of the individual groups.

8. After lunch, Mr G.M. Karanja (KARI), who had acted as chairman for the plenary session, summarized the discussions that had taken place.

9. A stimulating closing address was given by the Provincial Director of Veterinary Services (Eastern Province), Dr J.K. Kajume, in which he emphasized the need for Kenyans to work closely with expatriates with a view to promoting development and achieving technical and financial independence.

CONCLUSIONS

The participants at the workshop were broadly in agreement with the proposals put forward by the project staff, although several valuable observations and suggestions emerged from the group discussions. These will be taken into account in designing the final programme. Participants welcomed the opportunity to voice their opinions at the planning stage and looked forward to working with the programme at the farm level. They expressed a desire to be included in similar gatherings in the future, where results of the research should be presented.

Paper 2.

ANIMAL NUTRITION START-UP WORKSHOP, June 1994

Summary of Group Discussions

Comments on Proposed Research Activities

Workshop participants were divided into separate groups to discuss on-farm, on-station and dryland proposals. The groups then reported to a plenary session where their recommendations were further discussed. The following is a summary of the conclusions as agreed by the plenary session.

ON - FARM RESEARCH

a) Emphasis should be placed on farmer selection (willingness to cooperate, farm and animal situation, etc.).

b) The feasibility of transfer of forage from the research centre to the participating farms should be considered if the farms do not have sufficient tree fodder (farms should be in the vicinity of the Embu Regional Research Centre).

c) Participation by the farmer will depend on the type of technology to be introduced and farmer perception of its benefits and risks.

d) The cost of production of fodder from trees relative to the value of benefits realized should be determined.

e) While it was recognized that the experimental details should be left to the criteria of the experimenters, it was suggested that a wide range of ratios of tree fodder to concentrate (dairy meal) should be included in the studies.

f) Concern was expressed regarding possible side-effects of the feeding of *Calliandra calothyrsus*, especially at higher levels of inclusion in diets for dairy animals.

ON - STATION RESEARCH

Propagation Studies

a) Attention should be paid to possible toxic effects on animals before selecting the tree species for experimentation.

b) Emphasis should be placed on indigenous, multi-purpose tree species. Mururi (*Commiphora zimmermanii*) was mentioned as a particularly useful dryland species.

c) Collaboration was suggested with the Environmental Plan of Action for work with indigenous trees. Details of this programme would be made available by the Provincial Director of Veterinary Services, Embu.

Digestibility Studies

Emphasis in this work should be on diversity of tree species as an insurance against destruction by pests and diseases.

Feeding Studies

a) The effects of feeding of tree fodder may be noted in the quality of both meat and milk (colour, off-flavour, etc.). These effects should be assessed.

b) The priority rating of farmers regarding the importance of cattle vs. goats should be considered. The matter of which species should be used as the test animal was raised. It was questioned if results of feeding studies on goats could be reliably extrapolated to cattle.

c) Goats and cattle should be compared in the nutritional studies for their potential and efficiency for milk production.

DRYLAND RESEARCH

The term "dryland" needs to be defined in order to specify the areas of interest in each district.

Orientation of the Research

a) The objectives of the farmers and their indigenous knowledge, particularly with regard to trees for use as medicines and animal feed, need to be considered.

b) Currently, the drylands are in a state of transition due to increasing human population and fragmentation of land holdings. The number of trees is decreasing and policies (and possibly sanctions) may be needed to protect trees. Block planting of trees may lead to increased competition with crops, although scattered individual trees may be acceptable.

c) Tree planting should be geared to attempts to improve the economic performance of farming in the region.

d) Beef production is of higher priority than dairy, although in Tharaka-Nithi, goats are more important than cattle.

Research Recommendations

a) The livestock production potential of the drylands needs to be assessed so that research can be aimed at exploiting that potential. Studies should define the number of trees (and the area that they occupy) needed for specific animal enterprises; ways to fit supplementary feeding of trees into the farming systems; and the interactions of both indigenous and exotic trees with existing grass pastures.

b) Anti-nutrient factors in the foliage may protect some trees from over-utilization during periods of plenty, creating a reserve of fodder that can be used during times of feed shortage. While their influences may not be totally negative, their effects on animal production should be studied. The management necessary to obtain benefit from potentially toxic fodder species is of great importance.

c) Research should cover a wide range of both indigenous and exotic species. The improvement of indigenous species should be undertaken in terms of propagation and genetics (selection from local populations). It may be possible to transfer some trees (e.g. *Croton megalocarpus*, mukinduri) from the high potential areas to the drylands, although concern was expressed regarding the possible movement of pests and diseases from exotic species to the useful native trees.

Paper 3.

Proposed Workplan

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8 July 1994

Since the arrival of the undersigned in February 1994 to work in the ODA-funded Agroforestry Livestock Feeding Systems programme within the National Agroforestry Research Project based at the KARI Regional Research Centre in Embu, many discussions have been held with KARI, KEFRI and ICRAF staff based in both Embu and Nairobi in order to define a work programme that is both relevant and acceptable to all of the many parties involved. These discussions, together with a study of secondary sources of information, resulted in the preparation of a draft work programme which formed the basis for a workshop for District and Provincial Agricultural, Livestock and Forestry Officers from Central and Eastern Provinces. This was held in Embu on 16 and 17 June 1994 and led to the formulation of generally agreed proposals.

In the period from 29 June to 4 July 1994, Dr E. M. Gill, Head of the Livestock Section of the Natural Resources Institute (NRI) and Project Manager from the point of view of the donors, visited Kenya where she had discussions with senior KARI and ICRAF staff in Nairobi, saw the project site and facilities in the Embu region and took the opportunity to participate in a detailed examination of the draft proposals that had been prepared before her arrival. During the final discussions in Embu, ICRAF was represented by the Regional Coordinator for the East African Highlands and KARI and KEFRI were represented by local project staff.

The attached document sets out the results of the deliberations which took place in Embu. It will be submitted to the donor administration where it is expected to be accepted as the final work plan for the period of agreed funding to March 1996. Under cover of this letter it is circulated to interested parties in Kenya.

Dr R. T. Paterson
Animal Scientist

PROJECT NUMBER R5732 ref 237, Development and on-farm evaluation of agroforestry livestock feeding systems NRI/ICRAF/KARI/KEFRI

PROPOSED WORK PLAN

The project entitled "Development and On-farm Evaluation of Agroforestry Livestock Feeding Systems" is funded by the Overseas Development Administration (ODA) of the British Government through the Forestry Research Programme, with additional funding from the Livestock Production Programme and the Agronomy and Cropping Systems sub programme of the Natural Resources Institute (NRI). It is carried out in conjunction with the International Centre for Research in Agroforestry (ICRAF) and is based in Kenya. It is physically located at the Regional Research Centre, Embu (RRC), a station which belongs to the Kenya Agricultural Research Institute (KARI) and has as its mandate area seven districts including both the high potential land of the tea and coffee-based land use systems and the arid and semi-arid lands surrounding Mount Kenya. It is included within the National Agroforestry Research Project, a collaborative initiative involving KARI, the Kenya Forestry Research Institute (KEFRI) and ICRAF. This umbrella project, which in turn operates within the East African Highlands Agroforestry Research Networks for Africa (AFRENA), has in the past concentrated its efforts in the areas of high agricultural potential, but is now seeking to spread into the drier areas.

Original ICRAF survey work in the area (Minae, S. and Nyamae, D., 1988. Agroforestry Research Project Proposal for the Coffee Based System in the Bimodal Highlands, Central and Eastern Provinces, Kenya. AFRENA Report No. 16) noted that 83% of the farmers in the area kept cattle (typically one cow, one heifer and a calf), 77% kept goats and most also kept chickens. The ruminant animals were kept almost exclusively under conditions of zero-grazing. It is likely that since that time, the proportion of farmers keeping livestock on these very small farms (average size, 1.5 ha) has increased in response to poor coffee prices in the last few years. Livestock is important both for cash generation (milk, sale of surplus stock) and for subsistence (milk, meat and eggs).

Within the higher potential areas, most of the indigenous tree species have been removed, although the farms carry a high tree density, as farmers have actively planted exotic trees, mainly for fruit, timber, poles and firewood. In the drier areas, there is much less reliance on imported trees as the indigenous species have not yet been removed. Throughout the region, selected indigenous species are managed and protected as valued sources of dry season feed for livestock.

As part of the activities of the National Agroforestry Research Project, fodder trees have been introduced onto a number of farms in the Embu region. Hedgerows of *Sesbania sesban, Leucaena leucocephala* and *Calliandra calothyrsus* were established in on-farm trials to measure biomass production under regular cutting regimes. In general terms, the first species failed to persist under frequent defoliation, while the second was badly attacked by the

Leucaena psyllid (*Heteropsylla cubana*) which arrived in the region at the end of 1992. The *Calliandra* appears to be largely resistant to pests and diseases and has proven to be both persistent and productive. It is popular with those farmers who have experience with it, most of whom are actively seeking more seedlings to extend their plantings. No information exists, however, on optimum inclusion levels of the fodder in animal diets. The generation of such information is part of the justification for the present project.

The proposed work plan for the project can be subdivided into a number of themes as follows.

1. Fodder availability for small-holder livestock

A number of surveys conducted in the region since 1988 highlight both the scarcity of fodder and the lack of quality (mainly protein) in animal diets, particularly during the dry seasons. Tree fodder can help to overcome these problems, but there is a lack of information regarding suitable inclusion levels and optimum feeding management strategies. Work will be initiated on-farm, with dairy cattle, to study the effect of tree fodders on animal productivity.

2. Tree fodder as a replacement for concentrate rations

Concentrate rations are available in population centres in the region but farmers without their own transport face logistical problems in moving bulky material from the towns to their farms. They frequently complain of variation in the quality of purchased feeds, claiming that the cost is too high for products in which they have little confidence. Tree fodder can represent a reliable source of home-grown feed that requires little cash expenditure after the establishment phase. It is necessary to estimate the replacement value of the tree fodder in comparison with commercial concentrates. Such information will be of value in the economic assessment of the use of trees for animal production and in the formulation of practical fodder production and utilization recommendations for farmers.

3. Indigenous trees

Indigenous trees are utilised by farmers for feeding both cattle and goats but little is known about either their feeding quality (nutrient content and digestibility) or the possible presence of anti-nutrient factors. Information is also lacking about suitable systematic management practices for sustained productivity. In view of the importance of indigenous trees, particularly in the drier areas, work will be undertaken to evaluate some of the most popular species from the point of view of animal production.

4. *Calliandra calothyrsus*

This species has emerged as a favourite of farmers in the higher potential region. Although it shows good agronomic characteristics, it is not without problems for animal production. It is known to have a high tannin content and this may be involved in the apparent rapid decrease in digestibility within hours of being cut. Stress factors (soil fertility, shade, climate) are known to influence the tannin content of various plant species. The effect of stress on the digestibility of *Calliandra* should be studied in order to refine management recommendations.

The proposed work programme is detailed below.

1. **SURVEYS** (June - December 1994)

a) In view of the number of farming systems surveys that have been carried out in the target area over the last few years, it was not thought necessary for the project to conduct another one before deciding on the work programme. A formal survey involving some 1350 households in the Embu District is being conducted (June - July 1994) across the whole project area with funding from IDRC and this will be followed by detailed case studies. A further survey with FAO funding is planned for the Runyenjes area. Information of use to the project will be extracted from these activities when they are completed.

b) An inventory and survey of existing tree nurseries will be conducted in the Muranga'a District to determine physical distribution, species availability, propagation practices, prices etc. The aim will be to encourage the decentralization of availability of recommended tree seedlings to make it logistically easier for farmers to meet their needs.

2. **ON - FARM RESEARCH**

a) The replacement of dairy meal by *Calliandra* fodder for milk production will be studied to determine the replacement value of tree fodder within existing production systems. RRC will constitute one site, with several others located on private farms. The experiment will be conducted in both the dry (July - September 1994) and the wet seasons (October - December 1994).

b) The use of tree leaf meal as diet extenders for chickens will be evaluated in collaboration with a local commercial egg producer. The objective will be to study ways to reduce the costs of poultry feeding. Initially, the work will be carried out with laying hens (October - December 1994). If feasible, it will subsequently be extended to broiler production (April - September 1995).

c) Goat production will be monitored on a number of farms in order to relate existing feeding and management practices to animal productivity (September 1994 -February 1995).

3. **ON - STATION RESEARCH**

a) One of the most valued indigenous fodder trees in the region, *Trema orientalis*, produces large amounts of seed, but germination is both poor and extremely slow. A study of seed pre-treatment will be conducted (June - September 1994) in an attempt to improve germination of this species. If this is unsuccessful, vegetative propagation methods, including the use of hormones, may need to be investigated. It may also be necessary to extend this work to other indigenous fodder tree species if problems are encountered (from October 1994).

b) The digestibility of *Calliandra calothyrsus* as affected by growing conditions, tree management and post-harvest handling of the fodder will be studied in order to optimise feeding strategies. This work will be dependent upon the availability of local laboratory facilities. The new office block and laboratories at Embu are estimated to require about three months of further work for completion but activities are currently stalled. It is hoped that the research will start in December 1994 and that results will become available from February 1995.

c) The digestibility of indigenous and exotic tree species by both cattle and goats will be studied in order to support the on-farm work. Particular attention will be paid to the plant parts which are actually consumed by the animals. Digestibility of both pure feed sources and mixtures as fed by farmers will be evaluated. As for point 3b) above, this work will be dependent upon local laboratory facilities (from December 1994 - September 1995).

d) In conjunction with 3 b) and 3 c) above, *in vivo* digestibility of feeds will be compared with laboratory results from common *in vitro* methods. This is necessary because anti-nutritive factors commonly found in tree fodder (tannins etc.) may affect the reliability of laboratory results. The objective of this work will be to identify the most reliable *in vitro* methods for use with the common tree species in order to reduce the need for *in vivo* evaluations in the future (from December 1994, depending on the local availability of laboratory facilities).

e) In order to design an effective research programme with goats, the first step will be to conduct a review of currently available information. Much work has been done in the region with these animals but the results are often noted in grey literature and are therefore relatively inaccessible. While this will be time-consuming, it will facilitate the design of an efficient programme to fill gaps in the knowledge with regard to the feeding of goats on tree fodder. It will also supplement information to be derived from the monitoring activity noted under section 2 c) above (August 1994 - February 1995).

4. DRYLAND RESEARCH

a) The ODA-funded Dryland Agricultural Research and Extension Project (DAREP) has completed two surveys in the drier areas of the KARI mandate region, one in Meru an the other in lower Embu. The IDRC survey noted under section 1 a) above, part of which is concerned with the arid areas, is being conducted at the time of writing. When the reports of these activities become available, it should be possible to extract from them an indication of the importance of indigenous trees and shrubs in the existing dryland animal production systems. It is expected that the reports will be ready in the period from July - September 1994 and they will be reviewed as soon as they are available.

b) In conjunction with 4 a) above, a review of available information will be made, concentrating on the use, feeding value, possible anti-nutrient factors and traditional veterinary uses of indigenous tree fodders (August 1994-March 1995).

c) Where exotic fodder trees already exist, they will be compared with indigenous species in terms of biomass production, speed of regrowth after cutting in both wet and dry seasons and feeding quality. This activity will start in August 1994 and will continue for the duration of the project.

d) From survey data, supplemented by direct observation where necessary, an inventory will be made of available feed resources in the drier areas with a view to identifying the major periods of feed shortage (August 1994 - August 1995).

e) The design of agroforestry interventions for further testing will follow the above activities. (from June 1995).

5. DISSEMINATION ACTIVITIES

a) A zero-grazing, agroforestry-based dairy unit will be established on about 0.75 ha of land at RRC. This will be used to demonstrate the integration of agroforestry techniques into intensive, small-scale dairying based on the feeding of Napier grass (*Pennisetum purpureum*). The systematic collection of relevant input (labour, fodder, chemicals, etc.) and output (milk, manure) data will be instituted when the system is fully installed (from June 1994 for the duration of the project).

b) Collaboration will be established with existing tree nurseries to promote the supply of desirable fodder tree species to farmers. This activity will be initiated during the survey work noted under section 1 b) above. It will therefore start in September 1994 and will continue for the life of the project.

c) On-going collaboration with the extension activities of other organizations such as the Dutch-funded National Dairy Development Project (NDDP), non-government organizations, Ministries etc. will be strengthened by the activities of the project (on-going, throughout the life of the project).

d) Results of the project will be disseminated in a range of ways as they become available. These will include meetings and workshops for farmers and extensionists, participation in national and regional meetings and seminars and preparation of papers for both popular and formal publications.

Paper 4

Major Constraints to Project Activities

The project workplan (paper 3 above) was based on a number of assumptions, some of which proved to be false. This led to the following constraints to project activities:

The field work for the IDRC survey of 1350 households across the region was completed during 1994, but ICRAF was unable to arrange for the analysis of the results. The crude data are available, but they have not been processed in any way. Similarly, the results of the DAREP surveys conducted in 1993 and 1994 did not become available until mid-1995. This lack of survey data delayed some project activities, particularly in the areas of lower agricultural potential.

2 It was assumed that the laboratory facilities at the KARI RRC in Embu would be commissioned by the end of 1994. Despite diverse attempts by many people, no progress had been made up to June 1996, either in completing the building or in setting up alternative local facilities for animal nutrition work.

3 During 1993 and 1994, many farmers in the area had difficulty in obtaining artificial insemination services for their dairy animals. This reduced the number of farms with young calves at particular times of the year. It proved to be impossible to conduct the planned evaluations of the effects of feeding of *Calliandra calothyrsus* on milk production during the wet seasons of 1995, because sufficient farms with cows at a suitable stage of lactation could not be identified. The only on-farm assessments were therefore carried out in the dry seasons of 1994 and 1995.

Part II

Technical Papers

Paper 5

Indigenous and naturalized fodder trees in Embu and Mbeere districts: Preliminary results of a survey

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Abstract

Fodder shortage especially in the dry season is a constraint to livestock production in Central Kenya, which can be addressed by growing indigenous fodder trees and shrubs (IFTS). A survey was carried out to identify current farmers' practices and knowledge of IFTS in the highlands and lowlands. A total of 90 farmers were interviewed, divided over three agro-ecological zones, and some results are presented. In the highlands the farms are the smallest and all cattle are upgraded dairy types. In the lowlands all cattle are of the local type. The largest farm sizes occurred in the intermediate zone, which as a result of this has the lowest livestock density. In the lowlands most farmers (90%) were interested to plant IFTS on their farms, possibly because of the high demand for fodder.

Mucimoro (*Lantana camara*) ranked high for planting on-farm and fodder quality assessed by farmers in the lower zones. Although the exotic type of *L. camara* is thought to have toxic properties, the indigenous type does not seem to have these problems. Other popular species were Mugiso (*Triumfetta tomentosa*) and Mururi (*Commiphora zimmermanii)* for the highland, Muuti (*Aspilia mossambicensis*) for the intermediate zone and Mukao (*Melia volkensii*) for the lowland. Mugiso shows potential as a feed for cattle as it is often used for it.

Diseases are not a major constraint to the production of IFTS. Utilization of IFTS only for dry season feeding occurs more in the lower zones. Further research is needed on the nutritive value of IFTS species and their agronomic potential.

Keywords

fodder trees, indigenous knowledge, farmers' preference

Introduction

Ruminant production is an important component of the farming systems in Central Kenya. An important problem diagnosed for the dairy zero grazing system in the coffee based land-use area is lack of fodder during the dry season and the protein content of the diet (Hoekstra, 1988; Minae *et al.*, 1988; Snyders, 1991). This problem is limiting the milk production which is one of the main income generating enterprises of the people. The situation becomes worse during the dry season when the quality of the grass is reduced.

In the arid and semi arid lands of Central Kenya farmers keep goats and cattle of local breeds or crosses and the normal management practice is extensive grazing. There is a tendency for the livestock system to become more intense as the communal grazing land is being adjudicated and less land becomes available for grazing. Farmers are therefore increasingly growing fodder crops but these are not sufficient in quality and quantity, especially during the dry season.

Many trees are eaten by livestock and have high nutritive values. The advantage of a tree crop is that it is deep rooted and can therefore produce green fodder during the dry season. Surveys conducted in the Central Kenyan highlands showed that farmers feed many different indigenous trees to their animals (Thijssen *et al.*, 1993; Murithi *et al.*, 1993). Indigenous fodder trees have the advantage over exotic ones that they are well adapted to the local environment and farmers know them. Very little is known about the quality aspects of these trees however.

This paper discusses some preliminary results of a survey that was carried out to know more about farmers' current practices and knowledge of indigenous fodder trees and shrubs (IFTS). The survey intends to rank the popularity of IFTS by farmers. Information was also sought about the quality parameters that farmers use to assess the usefulness of a fodder tree. Since the ecological conditions and farming systems vary a lot along the altitudinal gradient of Mt. Kenya the survey also intended to identify the difference in patterns of the use of IFTS in different agro-ecological zones (AEZ's).

Materials and methods

Three agro-ecological zones (AEZ) were taken into consideration:

	mean annual rainfall (mm):	altitude (masl):
UM2	1200-1400	1400-1600
LM3:	900-1000	1070-1280
LM5:	750- 800	830-1130

In every AEZ 30 farmers were selected from a sample frame. The frames consisted of 250-300 farmers. In UM2 the frame consisted of a list of all households in 8 adjacent villages. The list was made by the assistant Chief. In LM3 and LM5 no such list could be obtained. Instead, a primary school in each AEZ was consulted and lists of the parents of all the school children were made. Farmers were selected from these lists at random. The only selection criterion was to have at least one cow. Because goats are more indiscriminate tree foliage consumers than cattle, it was felt desirable to obtain as much information as possible on the consumption patterns of cattle. The farmers were interviewed with a formal questionnaire which had been tested before. Quality parameters that farmers use for assessing fodder trees were identified for each AEZ before the survey started. They were then used to let the farmers assess the fodder trees. Some parameters were different for each AEZ. The data were analyzed with the computer package SPSS. Only part of the results are presented in this paper, due to a time constraint for the analysis.

Results

Land-use

There is a large difference between the average farm sizes of the three studied zones; the largest is in LM3 (4.8 ha) and the smallest in UM2 (2.3 ha). The largest range of sizes is also found in LM3 (0.4 - 30 ha). In UM2 17% of the farmers have less than 0.6 ha. Most of these farmers however rent additional land. In LM3 and LM5 no one rents farm land. Communal grazing land is much used in LM3 and LM5 but not at all in UM2 (Table 1). Farmers in UM2 have the biggest areas of cultivated land and hardly any pasture. In LM3 and LM5 over 60% of the farmers own pasture and the average acreage is 2.7 ha (Table 1).

Animals

All cattle in UM2 are exotic or cross bred, there are no local cattle. In the driest area it is the opposite, all cattle are local. LM3 is a transition zone between the two in this respect. The highest number of total cattle per farm occurs in LM3 (Table 2). The number of farmers having goats and sheep increases when one moves towards the dry area. The same applies to the number of these animals per farmer (Table 2).

Use of fodder trees

When farmers were asked whether they could differentiate between exotic and indigenous trees, 97% in every zone replied positively. The proportion of farmers using exotic and indigenous trees for fodder in UM2, LM3 and LM5 were 68, 37, 48 and 93, 97, 100% respectively. The percentage of farmers using indigenous fodder trees as a hedge ranged from 63% in UM2 to 93% in LM3.

Planting trees

Farmers were asked whether they would plant IFTS on their farms if they were given seedlings. The proportion that said they would was 63, 76 and 90% for UM2, LM3 and LM5 respectively. The most popular species that farmers are interested in to plant on their farms are listed in Table 3

Practices of fodder trees

A total of 160 different species are used by farmers in the three zones to provide tree fodder. Table 4 lists the species that are considered most important for fodder, ranked from 1 to 5 for each AEZ. The top two species in Table 3 and 4 are quite similar. For the two most important species that farmers want to plant in each AEZ (Table 3) more detailed information is given in this section.

Mugiso, Masiso (*Triumfetta tomentosa*, UM2)

96 percent of the farmers that use this shrub feed it to upgraded cattle and 55% feed it to goats. Only one farmer planted the shrub, in all other cases it was established naturally. The most common place is off-farm but it is also left within the food crops, on contours and in the napier plots. The shrub is fed throughout the year and is normally cut at 0.5-1 m height. The parts that are fed are twigs and leaves. Other uses are ropes (72%) and fuelwood (61%). The shrub is sometimes affected by caterpillars (3 farmers).

Mururi (*Commiphora zimmermanii*, UM2)

80% of the farmers using this tree feed the fodder to upgraded cattle and 60% feed it to goats. All the trees on-farm are established by cuttings and they are planted within the food crops (85%) or on the external boundaries (50%). It is fed throughout the year (70%) or only during the dry season (25%). Most of the branches are pollarded, alternatively the tree is coppiced above 1 m height. The leaves and twigs are used for fodder and the bark is stripped of the branches if they are given to the animals. 95% of the farmers that use the fodder also use the tree as supports for growing yams. Other uses are fuelwood and live fences. The tree is sometimes affected by caterpillars (4 farmers).

Muuti (*Aspilia mossambicensis*, LM3)

This shrub is fed to local cattle (61%) and goats (100%). In all cases it is established naturally. It grows scattered within the grazing land (91%), within the fallow land (35%) and on the external farm boundaries (26%). It is mostly used throughout the year (74%) but in some cases only in the rainy season (17%). The shrub is often browsed (91%) and sometimes the soft twigs are cut (22%). The leaves and twigs is what the animals feed on. Only one case of a disease was recorded; the stems turn black.

Mucimoro, Mucirigu (*Lantana camara*, LM3 + LM5)

The following information is consistent for the two zones, except where mentioned otherwise. The shrub is fed to local cattle (51%) and goats (100%). It establishes naturally but in LM5 it is sometimes planted through cuttings (17%). The plant grows within the grazing land (89%) or on external farm boundaries (67%). It is fed throughout the year but some farmers in LM3 use it in the dry season only (32%). It is browsed by the animals (86%) or the soft twigs are cut (32%). The parts that are consumed are leaves (100%), twigs (66%) and fruits (50%). Other important uses are fuelwood (65%), timber and live fence. Only one farmer in LM5 mentioned caterpillars on the shrub.

Mukao (*Melia volkensii*, LM5)

Mukao can develop into a big tree if left uncoppiced. Its fodder is fed to local cattle (73%) and goats (100%). The tree is established naturally (69%) although some farmers plant seeds (12%). The germination of the seeds is very poor though. The tree grows within the food crops (92%) or cash crops (39%). Its fodder is used throughout the year (50%) or during the dry season only (50%). The fodder is harvested through pollarding or coppicing the tree above 1 m. The leaves (100%) and twigs (62%) are fed and also the fruits (62%). Feeding the fruits is believed to enhance the germination of the seeds. Mukao is much appreciated for its timber (100%), and sometimes fuelwood (54%). No diseases or pests were reported on the tree.

Tree qualities

Farmers assessed the qualities of their six most popular fodder trees by giving ratings for each quality. The average of the ratings for growth after establishment, regrowth after pruning, palatability for cattle and fattening potential are given in Table 5.

Discussion

From the information in Table 1 and 2 conclusions on livestock density can be derived. The area that livestock utilizes is not only the pasture but also the fallow land, especially in LM3 and LM5, where fallow periods are long and a considerable amount of consumable biomass can develop. Livestock density can be expressed as livestock units (LU) per ha available land. For ease of calculation a head of cattle can be valued as 1.0 LU and a head of small ruminants as 0.1 LU. Pasture and fallow land together counts as available land. Thus the livestock densities for UM2, LM3 and LM5 are 7.1, 1.7 and 2.7 LU/ha respectively. It is peculiar to note that the intermediate zone, LM3 has the lowest density, which is mainly caused by the larger sizes of the farms in this zone. There are relatively many new settlers in this zone and the land has not had a chance yet to be divided into smaller pieces for sons and grandsons. More farmers in LM5 use communal grazing land and government land, which is an indication that the land has not yet been adjudicated as much as in UM2 and LM3.

The higher grazing pressure in LM5 than in LM3 also explains why more farmers there are interested in improving the fodder availability by planting trees. In UM2 the pressure for cultivation is so high that land availability becomes a constraint for planting trees. However, 63% of the respondents in this zone said they were still interested in planting, despite a measured average tree density of 106 trees/ha (Thijssen *et al.*, 1993).

The species that rated highest for the quality parameters are also the ones that scored highest for planting on-farm in LM3 and LM5.

Mucimoro is a controversial shrub because it is claimed by scientists to be toxic. Digestive problems were sometimes associated by the farmers with the feeding of this fodder. Yet the shrub scored a high rating for planting on-farm. There seems to be a difference in toxicity between local and imported lines of *L. camara* though (Munyua *et al.*, 1990); indigenous shrubs might be less toxic. If the fodder is used as a supplement rather than a sole diet, toxic substances are likely to be diluted to harmless levels. The high protein content of 21.4% in the leaves (Thijssen *et al.*, 1993) makes it a suitable supplement. The shrub ranked high for planting on-farm in LM3 and LM5. The fact that it makes a very good dense hedge possibly contributes to this.

Mukao not only provides good fodder but is also a very good timber tree. Since in most cases the tree is allowed to grow tall, fodder is a more important product in the young stage when foliage is easily harvested and timber becomes more important at an older stage.

When some leaves of Mucimoro, Mururi and Mugiso were analyzed by Thijssen *et al.* (1993) the protein contents (dry matter basis) were 21.4, 14.1 and 17.7% respectively and the in vitro organic matter digestibility was 71.8, 37.6 and 52.4% respectively. These few data suggest that Mucimoro has the highest nutritive value of the three.

Diseases do not seem to be a major problem for IFTS, and caterpillars mainly occur in UM2

Conclusions

Mugiso is a promising shrub in UM2 from a cattle nutrition point of view, almost all farmers feed it to their cows. Mururi shows more potential in terms of other qualities. In LM3 Mucimoro has advantages of ease of establishment and use as a hedge. Work done by others show a promising nutritive value for it. Muuti seems to be slightly more appropriate for cattle. In LM5 Mukao is more appropriate for cattle than Mucimoro. Whether it can produce enough biomass though remains a question.

IFTS were more used for cattle in UM2 than in the other zones. This is likely to be a result of the importance and intensity of the dairy system there. Feeding IFTS as a dry season feeding strategy occurs more in the dry zones than in UM2. Cutting management is more dependent on the growth nature of the plant than on the AEZ.

For further assessment of the usefulness of the IFTS more research is needed on nutritive value of the fodder and agronomic performance of the trees.

Acknowledgment

The authors want to thank Mrs. A. Kithinji (MoALDM, Mbeere District) and K.J. Muriuki (student Moi University) and the farmers of Nemburi sub-location, Mbeti North-, Mbeti South- and Kianjiru locations for their precious cooperation.

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Table 1. Land-use of farmers in three AEZ's (n = 3 x 30).

	UM2	LM3	LM5
average farm size in ha (s.d.)	2.3 (1.5)	4.8 (5.0)	2.8 (2.0)
average cultivated area in ha	1.9	1.5	1.2
average fallow area in ha	0.33	0.35	0.68
average pasture in ha	0.10	2.8	0.85
% using communal grazing land	0	53	83
% using government land	0	0	30
% using other land (rented, relatives', other AEZ)	23	0	3

Table 2. Percentage of farmers having livestock and average number of animals on those farms, including young stock (n = 3 x 30).

	UM2		LM3		LM5	
type	**%**	**av.no.**	**%**	**av.no.**	**%**	**av.no.**
exotic cattle	60	2.8	13	1.5	0	-
cross bred cattle	50	2.5	13	2.5	0	-
local cattle	0	-	87	5.5	100	3.9
av. no. total cattle all farms		**2.9**		**5.3**		**3.9**
exotic goats	7	3	0	-	0	-
local goats	50	2.5	47	3.2	67	4.3
sheep	7	1	13	3.3	23	3.0
av.no. total small ruminants all farms		**1.5**		**1.9**		**3.6**

Table 3. Indigenous fodder trees and shrubs that farmers want to plant on their farms in three AEZ's.

	Species					
Rank	**UM2**	**no.r.**[1]	**LM3**	**no.r.**	**LM5**	**no.r.**
1	Masiso, Mugiso (*Triumfetta tomentosa*) Mururi (*Commiphora zimmermanii*)	5 5	Mucimoro, Mucirigu (*Lantana camara*)	10	Mukao (*Melia volkensii*)	18
2	Mugumo (*Ficus spp.*)	4	Muuti (*Aspilia mossambicensis*)	5	Mucimoro, Mucirigu (*L. camara*)	11
3	Muvevu (*Trema orientalis*)	4	Mucugucugu (*Crotalaria goodiiformis*)	4	Mutuva, Muruva (*Grewia tembensis*)	9
4	Kirurite (*Tithonia diversifolia*)	3	Kirurite (*T. diversifolia*) Mugiti (*Indigofera spp.*) Muthunthi (*Maytenus putterlickoides*)	3 3 3	Muuti (*A. mossambicensis*)	7

Number of respondents

Table 4. Most popular IFTS in three AEZ's.

	Species					
Rank	**UM2**	**no.r.**[1]	**LM3**	**no.r.**	**LM5**	**no.r.**
1	Masiso, Mugiso (*Triumfetta tomentosa*)	18	Muuti (*A. mossambicensis*)	20	Mukao (*M. volkensii*)	20
2	Mururi (*C. zimmermanii*)	17	Mucimoro, Mucirigu (*L. camara*)	19	Muuti (*A. mossambicensis*)	18
3	Mucatha (*Vernonia lasiopus*) Mukwego (*Bridelia micrantha*)	12 12	Muthunthi (*M. putterlickoides*)	15	Mucugucugu (*C. gooditiformis*)	14
4	Mucimoro, Mucirigu (*L. camara*)	11	Mutuva, Muruva (*Grewia tembensis*)	12	Mukuru (*Acalypha fruticosa*) Murangare (*Acacia ataxacanthe*)	12 12
5	Kirurite (*T. diversifolia*)	9	Mugiti (*Indigofera spp.*)	9	Mutuva, Muruva (*G. tembensis*)	11

Number of respondents who mentioned the species as one of the six most important IFTS.

Table 5. Average rating of qualities of IFTS (1 = poor, 2 = medium, 3 = good).

	UM2		**LM3**		**LM5**	
	Mugiso (*Tr. Tomentosa*)	Mururi (*C. zimmerm.*)	Muuti (*A. mossamb.*)	Mucimoro (*L. camara*)	Mucimoro (*L. camara*)	Mukao (*M. volkensii*)
growth after establishment	2.2	2.8	2.6	2.9	2.6	2.2
regrowth after pruning/coppicing	2.3	2.9	2.6	2.9	2.5	2.5
palatability for cattle	2.1	2.5	2.6	2.3	1.7	2.3
fattening (LM3, LM5)/ health (UM2)	2.4	2.7	2.8	2.6	2.2	2.3

Paper 6

Indigenous and naturalized fodder trees in Embu and Mbeere districts: Fodder intake trial

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Abstract

In a feeding trial, 5 heifers in a latin square experimental design were fed a basal diet of Napier grass (*Pennisetum purpureum*) with a supplement of one of the following trees: *Calliandra calothyrsus* (exotic), *Leucaena diversifolia* (exotic), *Manihot glaziovii* (naturalized), *Morus alba* (naturalized) or concentrates (Dairy meal). The dry matter intake of mulberry was significantly higher than that of the exotic trees, mulberry is as palatable as concentrates. Cattle even ate the bark. Because of the high protein content and digestibility of *M. glaziovii*, this tree provides the highest amount of digestible crude protein (DCP) per animal. It therefore has a good potential as a supplement to protein deficient diets of cattle. It is advised though to dry or wilt this fodder before feeding to eliminate any toxic effects.

Introduction

Indigenous trees have a great potential as a fodder supplement in the dry season when the dairy cattle are fed on Napier which has lost its nutritive value and which has come in short supply. The organic matter digestibility and crude protein content of the leaves of some indigenous trees which are traditionally used as fodder are very high (Thijssen *et al.*, 1993). On-farm however, not only the leaves are fed to the cattle but also petioles and the branches. The part that is eaten by the cattle varies per tree species. No research has been carried out yet on the nutritive value of the part of the tree fodder that is actually eaten by the animals. This experiment intended to fill that gap of knowledge. Some popular exotic trees in the area were also included in the experiment.

Objectives

1. To know which parts of the trees are consumed by cattle.
2. To determine some nutritive value aspects of the ingested tree fodder.
3. To compare the dry matter intake for each treatment

Materials and methods

Five Ayrshire cross bred heifers of about nine months age and 159 kg liveweight at the start of the experiment were kept in a zero grazing unit. In a latin square experimental design they were fed a basal diet of Napier grass (*P. purpureum*) with a supplement of one of the following trees: *Calliandra calothyrsus* (exotic), *Leucaena diversifolia* (exotic), *Manihot glaziovii* (naturalized), *Morus alba* (naturalized) or concentrates. The dry matter of the supplement offered was calculated for each animal at a rate of 0.625% of the liveweight (25% of the total intake which was estimated at 2.5% of liveweight) and was revised every two weeks. Each diet was fed for two and half weeks while offered and left over feed was recorded. The last three days the diameters of the offered and left over branches and twigs were measured. Live weight was recorded weekly. *M. glaziovii* was sun-dried before feeding, to destroy the cyanogenic glycosides.

Results and discussion

During the 15 weeks of the experiment the heifers grew on average 0.303 kg per day. This shows that young cattle fed with napier and tree fodder can obtain very satisfactory growth rates. Results from the laboratories have not been compiled yet. Dry matter assessments have been done at 60°C which produced the results shown in Table 1.

The first three weeks of the trial the total dry matter intake for all diets except the control was much lower than during the rest of the trial. The fact that the heifers were not used to consume tree fodder must have caused this. In Table 1 the averages of dry matter intake for the different diets are presented. The values for period 1, during which the intake was very low, are excluded. Total dry matter intake did not differ very much between the treatments. Differences of the intake of the supplements are very significant. The dry matter intake of mulberry was higher than that of the other trees and comparable to concentrates. Cattle even eat the bark of mulberry.

M. glaziovii showed the lowest intake but because of the high protein content and digestibility it provides the highest amount of digestible crude protein (DCP) per animal. It therefore has a good potential as a supplement to protein deficient diets of cattle. It is advised though to dry or wilt this fodder before feeding to eliminate any toxic effects.

The concentrates that were used provide a low amount of DCP; its role in cattle nutrition might be the provision of metabolizable energy rather than digestible protein. Mulberry and *L. diversifolia* provide amounts of DCP similar to concentrates, calliandra is slightly better.

With a simple calculation the milk production of dairy cows can be predicted. The requirement for every kg of milk that is produced is 45 g DCP. An average size dairy cow in the mandate area weighs about 300 kg, which is equivalent to 72.1 kg metabolic LW. If two cows of 300 kg liveweight are fed a basal diet of napier, while one receives a supplement of concentrates and the other a supplement of *M. glaziovii*, the latter cow will produce two kg more milk.

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Table Dry matter intake of heifers

Supplement	Total DMI (g/kg $LW^{0.75}$/ day)	Supplement DMI (g/kg $LW^{0.75}$/ day)	% crude protein (on DM basis)[1]	Digestibility (%) of crude protein[2]	DCP intake g/day/200 kg LW
Calliandra calothyrsus	114.2	17.55	28	65	170
Morus alba	115.7	22.25	15	85	151
Manihot glaziovii	114.4	14.49	35	80	216
Leucaena diversifolia	116.1	16.62	23	75	152
dairy meal	116.9	22.57	16	80	154
p sed LSD (0.05)		0.002 1.73 3.81			

Key: [1] source: Roothaert, R.L. and Paterson, R.T. (1997).
[2] Values listed are for organic matter digestibility (source: Thijssen *et al.*, 1993).

Discussions on Papers 5 and 6 (Roothaert)

Q. One of the quality parameters for fodder trees mentioned by farmers is "health". Is this related to medicinal properties of the trees?

A. This quality refers to the health condition of the animal. This is achieved through good nutrients and possibly substances that prevent diseases.

Q. Are there any farmers involved in the propagation and feeding of IFTS?

A. 95% of all farmers feed IFTS to their animals. In UM2, some popular species are planted by cuttings, but in the dry areas, all IFTS are established naturally.

Q You indicated high values for the digestibility of indigenous trees but you did not include them in the feeding trials. Why?

A. Trials have been planned to include them.

Q. Are farmers willing to plant IFTS and where?

A. Farmers want to plant them on boundaries and hedges around the farm.

Q. Apart from medicinal properties, some IFTS have been known to be toxic. Is there any information on this?

A. For example, the exotic species of *Lantana camara* is toxic, but the indigenous species is not toxic. There is therefore need for work to be done on the indigenous *Lantana* species. Other toxic species are some Acacias, which can induce abortion in animals.

Q. Despite the high nutritive value of the avocado fruit, there have been cases reported of goats dying after feeding on avocado leaves.

A. Some improved varieties of avocados are toxic if leaves are consumed by goats and cattle in big amounts. Dogs feeding on it's fruits have been reported to suffer from cardiac failure. The indigenous type of avocado, the one that produces big fruits, is not toxic.

Q. Can avocados be fed to pigs?

A. Yes, they can, although one farmer complained that his pigs suffered from swollen belly after eating the fruits. The NARC-Muguga in conjunction with NAHRC-Naivasha are planning to conduct some trials to determine whether there are any toxic effects due to feeding of avocados to animals.

Paper 7.

Goat monitoring in the high agricultural potential areas of Embu district

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Abstract

Goat production activities were monitored on eight farms for a period of a full year from early 1995. It had been planned to select farms based on two separate criteria in order to have four possible combinations of the following factors; farms that were either part of a goat production improvement scheme or which were run almost independently (non-scheme); and farms with either cross-bred, or local animals. Unfortunately it was not possible to find farms where non-scheme farmers had cross-bred animals, so only three groups were used.

The major feed resources utilized were Napier grass, Sweet potato vines, Banana leaves, Avocado leaves, Kikuyu grass, Star grass, Wandering Jew, Banana stems, Bean stover, Maize stover, Kales, Banana peelings and Potato peelings. Although there was a tendency for goats on scheme farms to be more productive, differences between the two categories of farms (scheme and non-scheme) were not great and were probably a reflection of better animal husbandry practices and not breed differences. The benefits from the higher goat productivity in scheme farms may be offset by the higher cost of better animal husbandry required due to improved breeding.

Some of the local goats (that do not require high animal husbandry measures) may have the potential for reasonable milk production and thus selection for this and other desirable traits can be carried out within these breeds. Local breeds of goats, together with their crosses to a range of exotic breeds, and pure exotic breeds should be subjected to animal trials under similar management and feeding regimes so as to establish their production potential.

At present, there seems to be limited use of fodder trees in the diets of goats. There is therefore need to determine the effect on growth rates and milk production of incorporation of various levels of fodder trees in the "basal" diets of goats.

Introduction

The importance of small ruminants in many production systems is thought to be due to several factors. These include their low initial capital and maintenance costs; their ability to utilize marginal land and crop residues to produce milk and meat in readily usable quantities; and the short time lapse between birth and physiological maturity (Ngategize, 1989). In some areas, there are strong preferences for goat meat, and small ruminants play an important role in the fulfillment of traditional, social obligations such as payment of dowry.

The population of sheep and goats in Kenya is estimated at 19 million head (KARI, 1991). The majority of the small ruminants are found in the semi-arid areas. However, about 77 percent of the farmers in the coffee-based land use system of the bimodal highlands within Central and Eastern provinces of Kenya keep goats (Minae and Nyamae, 1988). The common breeds are the indigenous small East African, and various exotic milk purebreds (Saanen, Toggenburg, Alpine, etc.), and their crosses with the indigenous breeds.

There is one main type of production system that exists for goats in the high agricultural potential areas of Central and Eastern Kenya. Small-scale farmers practice stall feeding of purebred exotic, or crossbred/local goats, accompanied by high/medium/low animal husbandry levels.

At the start-up workshop on 16-17 June 1994 of the Overseas Development Administration (ODA) funded project R5732 ref. 237 entitled, "Development and on-farm evaluation of agroforestry livestock feeding systems" under the umbrella of the KARI/KEFRI/ICRAF National Agroforestry Research Project (based at RRC-Embu), goat production was identified as an important area in need of research interventions. In order to design an effective research programme for goats, the first step was to conduct a review of currently available information. Some work has been done in Eastern and Central Africa region with goats, but the results are often noted in grey literature, and are therefore relatively inaccessible. The review was completed early in 1995 (Paterson, unpublished). The review and information to be derived from the goat monitoring activity would facilitate the design of an efficient programme to fill gaps in the knowledge with regard to the nutrition and other management practices of goats.

Broad Objective

Goat production in Manyatta division (Embu district) was monitored for a period of one year (2 March 1995 to 28 February 1996). The main objective was to find out the existing feeding and management practices and to attempt to relate these to goat productivity.

Hypothesis

The plan was to divide small-scale mixed farmers into two categories; those keeping indigenous goats, and those keeping crossbred/purebred goats. Within each category of farmers, a further subdivision was made so as to have "scheme" and "non-scheme" farmers. "Scheme" meant someone who was part of a goat improvement group/collaborating with improvement schemes, and "non-scheme", meant someone who basically worked independently. The hypothesis being tested was that there is higher goat productivity, although at a greater cost of inputs, in the scheme farms (irrespective of the type of breed) since these farmers probably take better care of their goats than those in the non-scheme farms.

Methodology

Eight farms were selected and the number in each category was:

Crossbred/purebred goats - Scheme: Two.
Crossbred/purebred goats - Non-scheme: Although efforts were made to identify farms within this category, the search was fruitless.

Indigenous goats - Scheme: Three.
Indigenous goats - Non-scheme: Three.

Table 1 shows the number of goats at the start of monitoring in each of the farms. At the beginning, the farmers were visited at least once per week by a technical officer who helped them to complete the records. After the first few months, visits were made on a fortnightly basis. The farmers recorded most aspects of production with regard to their goats, viz. Feed resources - type and quantity of feed (forages and concentrates) offered each day, amount of mineral salts and water offered; Animal health measures - vaccinations, dipping/spraying, internal parasites and mastitis control; Animal reproduction issues - age at first service, type of buck used for service, gestation length, kidding interval, number and weight of kids born; Socio-economics - person looking for forages for the goats and the time spent; Animal performance - milk production, lactation length, growth rate of kids; and Manure production.

Results and Discussions

Scheme farms keeping crossbred/purebred goats will be referred to as **Scheme-A**. Scheme farms keeping indigenous goats will be referred to as **Scheme-B**. Non-Scheme farms (keeping indigenous goats) will be referred to as **Non-scheme**.

Table 2 presents a summary of the comparison of some aspects of animal production in the scheme and non-scheme farms during the monitoring period. Annex 1 provides the details of the aspects of production recorded by each of the farmers.

Feed Resources:

Within Manyatta division of Embu district, goats are raised under intensive systems, whereby there is use of stall-feeding. Even though goats prefer to browse, they can be raised quite effectively under this kind of system feeding on cultivated forages, weeds, and crop residues.

Results from the monitoring activity show that almost similar feeds are used to feed goats in the scheme-A and -B, and non-scheme farms. There seems to be no "basal ration" for goats in the region since at any one time, various forages are utilized. The forages include mixtures of Napier grass, Sweet potato vines, Banana leaves, Avocado leaves, *Triumfetta* spp., Kikuyu grass, Star grass, Wandering Jew (*Commelina benghalensis*), Banana stems, Bean stover, Maize stover, Kales, Banana peelings, Potato peelings, *Lantana camara*, etc. Goats can choose an adequate diet from poor quality forages and derive reasonable nourishment from them.

Dry matter (DM) is an important consideration since it reflects capacity, in terms of voluntary feed intake, to utilize feed. In the tropics and sub-tropics, the DM intake capacity for meat goats is 1.8 to 3.8 per cent of body weight, while in dairy goats, it is 2.8 to 4.9 per cent of body weight (Payne, 1990). These figures indicate that the daily fresh feed requirements for meat and milk goats (assuming 30 kg bodyweight and 25% dry matter content of the feed) would be 3.36 and 4.62 kg/goat, respectively. The results from monitoring indicate that the farmers are feeding enough quantities of forages to their goats. The non-scheme and scheme-B farmers seem to feed more forage to their goats than the scheme-A farmers (7.4, 7.2, and 6.6 kg/goat/day, respectively. The intake of feed by individual goats was, however, not determined. The scheme-B and non-scheme farmers fed more crop by-products and residues to their goats than the scheme-A farmers. This is probably because the crop by-products were in more supply and hence their greater use in scheme-B and non-scheme farms. It is worth noting that the scheme-A farms are situated in the tea/dairy zone [LH1] (Jaetzold and Schmidt, 1983). This zone has most of the area under the cash crop (tea) with very little area under food crops and hence there is low production of crop residues and by-products.

It is apparent that there is limited use of exotic fodder trees (e.g. *Calliandra calothyrsus*), and indigenous shrubs and trees (e.g. *Tithonia diversifolia*, *Trema orientalis*, and *Vernonia lasiopus*). There is potential for incorporation of fodder trees in diets of goats since, for example, in Central Tanzania, separate groups of local goats with an average initial age of 8 months grazed on natural pastures and were supplemented at night *ad libitum* with sun dried leaves and small twigs of either *Cajanus cajan, Leucaena leucocephala or Sesbania sesban*. The mean intakes of the fodder trees were 82, 81, and 76 grams/day, respectively. Supplemented animals gained weight faster than the unsupplemented controls in both dry and wet seasons. There were no significant differences in animal growth rates between the tree species (Otsyina *et al.*, 1994).

Dry matter intake capacity is dependent on whether the forage is fed alone or with concentrates; the later generally increase overall DM intake (Payne, 1990). With regard to commercial concentrates (Dairy meal and bran), there is marginally higher use in both the scheme-A and -B farms than in the non-scheme farms (0.88, 0.92 and 0.80 kg/goat/day), respectively. The levels of concentrate supplementation seem adequate since it has been shown that after kidding, supplementation at 0.5 kg/day of dairy meal per lactating goat is adequate as long as the basal diet is of acceptable nutritive value (AIC, 1988).

Most scheme and non-scheme farmers were able to supply their goats with mineral salts and water *ad libitum*. Mineral supplementation is necessary since, for example, the daily mineral requirements of a 30 kg liveweight doe producing 2 kg of milk daily are in excess of the minerals available in a diet (Payne, 1990). Adequate drinking water should be available to goats at all times.

Animal Health:

Some of the issues covered under animal health are highlighted below.

Vaccinations:
In goats, vaccinations are necessary against the following diseases; Contagious Caprine Pleuro-Pneumonia (CCPP), Anthrax, Foot and Mouth Disease, and Tetanus (AIC, 1988). The results indicate that only the scheme-A farmers carried out vaccination against CCPP. Nonetheless, one case of CCPP was registered in a scheme-A farm. None of the other diseases were recorded in any of the farms.

Tick control:
Standard measures include dipping, hand spraying or picking. Hand picking and spraying may be the most suitable since goats have been shown to dislike being thoroughly wet as would happen if they are dipped. None of the scheme-A and non-scheme farmers carried out any tick control

measures. Only one of the scheme-B farmers sprayed his goats. However, no tick-borne diseases were recorded in either scheme-A and -B/non-scheme farms.

Internal parasites control:
Standard measures are routine dosing using anthelmintics once or twice a year at the onset of rains. In places where goats are grazed, rotational grazing can reduce the risk of worm infection (AIC, 1988). All the farmers kept their goats under stall-feeding and four of the scheme farmers (2 in scheme-A and 2 in scheme-B) dewormed their goats, while only one of the non-scheme farmers dewormed his goats. The rest of the goats were not dewormed. The system of feeding goats is such that their feed is hung above ground and hence the chances of consuming worms is low. Incidences of worm infestation were not observed in any of the farms.

Mastitis control:
Control measures are similar to those of dairy cattle (AIC, 1988). In the monitoring activity, no cases of mastitis were recorded. This is probably due to the low level of milk production and the farmers are probably conversant with proper milking techniques. There is also the element of the small sample size of the farms monitored.

Other animal health measures:
Hoof trimming was carried out in both scheme-A and scheme-B farms. There was a minor case of diarrhoea in a scheme-B farm, and eye problems in scheme-B and non-scheme farms. There were no diarrhoea and eye problem cases in scheme-A farms probably due to better management.

Animal Reproduction:

Age at first service:
One of the factors influencing the economics of goat production is age at first kidding. Therefore, where goats kid for the first time at an early age, there is a greater population turnover. Even though sexual maturity is achieved at about six months of age, management practices are often designed to delay mating until the does are near to mature body weight so that pregnancy does not coincide with the period when the does are actively growing. It is therefore recommended to mate does at about 12 months so that they kid for the first time at about 18 months of age (Payne, 1990).

Results from the goat monitoring activity indicate that the farmers are breeding their goats later than recommended. This has the effect of reducing the long term production of goats. On average, the scheme farmers bred their goats at a later age than the non-scheme farmers (scheme-A; 17.0 - 29.5 months, scheme-B; 17.0 months; non-scheme; 12.0 months). It was noted that some scheme farmers did not serve their does at the recommended time because they were waiting for the arrival of the exotic Alpine buck in the area. The non-scheme farmers used the local buck. The age at first service of the goats in Manyatta division (Embu district) compares well with the age at first conception (16 months) under village conditions in Malawi (Cooper *et al.*, 1994).

Gestation length:
For several breeds of goats in the tropics, the gestation length has been found to be fairly constant at about 146 days; ranging from 145 to 148 days (Payne, 1990). This is comparable to the gestation length in the scheme-A, scheme-B, and non-scheme farms, which was 146.5, 146.0 and 147.0 days, respectively.

Kidding interval:
The kidding interval was longer in the scheme-A farms (315.0 days) than in the scheme-B farms (270 days). The kidding intervals in the scheme farms were long probably due to the longer lactation period of milk goats as compared to meat goats (Payne, 1990). Kidding intervals were not determined in non-scheme farms. The figure in scheme-B farms compares with that in Malawi, whereby the kidding interval was in the region 260 - 270 days for local goats (Cooper *et al.*, 1994). In India, the kidding interval for purebred and crossbred Anglo-Nubian goats, was 327 and 204 days, respectively (Payne, 1990).

In most tropical goats, oestrus occurs all the year round. Annual kidding appears to be characteristic of temperate breeds in the tropics and some tropical and sub-tropical breeds and is partly probably due to genetic factors (Payne, 1990). Another factor that can affect the incidence of oestrus in goats is seasons. For example, total annual rainfall and the percentage of does kidding or kids born have been shown to be significantly correlated (Payne, 1990).

Average number of kiddings per doe per year:
The pattern for most indigenous goats in the tropics is to have at least one kidding per year although two are possible (Payne, 1990). Within the period of monitoring, most of the does kidded at least once.

Twinning is common in goats. In the scheme-A and -B farms, 66% of the kiddings were twins, while in the non-scheme farms, 20% of the kiddings were twins. In the scheme-A farms, the ratio of number of kids born : number of breeding females was 1.43, while the ratio was 1.25 in the scheme-B farms. The ratio in the non-scheme farms was 1.0. This means that there is more animal productivity in the scheme farms than in the non-scheme farms. Some figures of average litter size are 1.8 from the West African Dwarf in Nigeria and 1.5 from the Alpine in India (Payne, 1990).

It has been shown that prolificacy increases with age. Fertility in goats appears to be maximum at about 5-6 years of age (Payne, 1990). The age of the does at the start of monitoring was not determined.

The dam's weight influences litter size and does which are heaviest at kidding tend to produce large litters (Payne, 1990). Even though the weight of dams was not recorded during monitoring, it is likely that the dams were heavier in the scheme farms (since they were crossbreds with exotic blood) and hence produced larger litter sizes.

Animal Performance:

Milk Production:
Results from the goat monitoring activity indicate that there was more milk production from the scheme-A farms (peak production; 0.88 litres/day) than from the scheme-B farms (peak production; 0.6 litres/day). In the non-scheme farms, the kids were allowed to suckle the dams, and hence the milk output recorded was lower (peak production 0.3 litres/day).

In the tropics, milk yields from local goats under a system of once-per-day milking while rearing a kid are generally low. For example, the daily milk yield of the West African Dwarf indigenous goat in Nigeria is 0.3 kg (Payne, 1990). In a study in Malawi, lactation yields ranged from 1.5 to 61 litres produced in about 117 days. The removal of this milk started 25 days *post partum* (Cooper *et al.*, 1994).

Exotic goats have been introduced in the tropics so as to improve milk production. Some breeds include the Alpine, Anglo-Nubian, Saanen, and the Toggenburg. In most cases, the exotic goats have been crossbred with the local goats, for example, Alpine goats have been crossbred with Indian goats (Payne, 1990), while in Kenya, the Saanen and Toggenburg breeds have been used widely in the high agricultural potential areas.

The Anglo-Nubian, used for both meat and milk production has consistently done well in environments into which it has been introduced. For example, in Malaysia, the F1 generation of the Anglo-Nubian and the local gave an average milk yield of 296 kg during a lactation period of 235 days (Payne, 1990). This averages to about 1.26 kg/day.

The Saanen is particularly vulnerable in environments where there is no shade and poor nutrition. Daily milk yields of up to 3.3 kg/day have been reported in India, but only 1.1 kg/day in Venezuela whereby, the Toggenburg gave a daily yield of 1.0 kg (Payne, 1990).

Lactation length:
In the goat monitoring exercise, the lactation length was about 125.0 and 127.5 days in the scheme-A and scheme-B farms, respectively. This compares with the lactation length of 126 days of the West African Dwarf indigenous goat in Nigeria (Payne, 1990) and that of indigenous goats (117 days) in Malawi (Cooper *et al.*, 1994). The lactation length was 107 days in the non-scheme farms.

Weight of kids born:
Twin kids were heavier in the scheme farms than in the non-scheme farms (scheme-A; 2.5 kg male, 2.3 kg female, scheme-B; 2.0 kg male, 2.0 kg female, and non-scheme; 1.75 kg male, 1.75 kg female).

For single births, the weights were, scheme-A; 3.0 kg male, 2.5 kg female; scheme-B; 3.5 kg male, 2.0 kg female, and non-scheme 2.75 kg male and 2.0 kg female. Generally, male kids were heavier in the scheme farms than in the non-scheme farms and single birth kids were heavier than twin birth kids.

Overall, it is likely that the better care of pregnant does in scheme farms may have contributed to higher birth weight of kids in these farms.

Growth rate:
The body weights of the mature goats were not measured and hence their growth rates could not be determined. The growth rates of unsupplemented local goats kept under on-farm conditions in various countries in Eastern and Central Africa were as follows: 0-4 wks; 40 g/day, 4-12 wks; 21 to 74 g/day; 12-24 wks, 22 to 48 g/day; 24-52 wks, 40 to 51 g/day. Unsupplemented animals can gain liveweights at modest levels of 10 g/day when the fodder on offer is inadequate in either quantity or quality. This is especially so in the dry season or when the animals are tethered or confined during crop growth (Paterson, unpublished).

The average growth rate (0 to 13 wks) recorded in kids in one of the scheme-A farms was 93 g/day. This growth rate is higher than that recorded in the places referred to above. However, in Fiji, stall-fed meat goats given sugar-cane tops, stovers and straw, coconut cake, rice bran and molasses under very intensive systems of management reached 23 - 25 kg liveweight in about 22 weeks (a gain of 154 g/day), compared to 83 g/day in extensive systems of management (Payne, 1990).

Even though there was limited use of tree fodder, it has been shown that feeding of goats on tree fodder can increase weight gains. For example, in the highland region of Rwanda, goats fed on mixtures of *Setaria splendida* grass (7-10% CP) and the tree fodder *Mimosa scabrella* (that does well higher than 2300 m above sea level) gained 50 g/day compared with 31 g/day while feeding on grass alone (Niang *et al.*, [in press] cited by Roothaert and Paterson, 1997).

Kid mortality:
During the monitoring period, about twenty-seven kids were born (twenty in the scheme farms and seven in the non-scheme farms). One of the kids in a scheme farm became sick and died, and hence the overall mortality was 3.70 percent. The majority of kid mortality takes place in the first 30 days of life (Paterson, unpublished).

Manure Production:

The average amount of manure collected over the whole monitoring period was 29 wheelbarrows (in scheme-A), 33 wheelbarrows (in scheme-B) and 300 wheelbarrows (in non-scheme) farms. The data would suggest that more manure was produced in the non-scheme farms than in the scheme farms. This is not necessarily the case since the scheme farmers raised their goats on slated raised floor houses with only goat manure accumulating under the slates for later collection, while in the non-scheme farms, the goats were kept on floors and hence the manure collected included refused forage and other waste material thrown in by the farmers. Further, the quantity of manure produced may be misleading, since the water content of the manure was not determined. Previous studies within the region indicate that the dry weight of a wheelbarrow-load of goat manure is about 10 kg (Josiah Gitari, pers. comm.).

Socio-Economics:

Labour supply:
It was noted that in seven of the farms, family members took care of the goats. There was a hired worker in one of the scheme-A farms. The wives took care of the goats in the scheme farms, while the husbands played the leading role in the non-scheme farms. This is probably a reflection of the assumption that women are better able to take care of "delicate" animals than men and hence have the primary responsibility in taking care of the purebred/crossbred goats in the scheme-A and scheme-B farms.

Time spent looking for forages for the goats:
The data indicates that the non-scheme farmers spent more time (1 hr 47 minutes) than the scheme-B (59 minutes) farmers looking for forage for their goats. The scheme-A farmers spent almost

equal time (1 hr 43 minutes) as the non-scheme farmers looking for feeds but offered lower quantities of forages. Scheme-A and non-scheme farmers looked for feeds outside the farm and hence spent more time than scheme-B farmers. The Scheme-B farmers spent the least amount of time looking for feeds but the quantities fed were almost as those in the non-scheme farms. The amount of time spent looking for feeds is probably a reflection of the feed resource endowment of the small sample of farms that was monitored and not the relative importance attached to the various categories of goats.

Conclusions/Recommendations

Although there was a tendency for goats on scheme farms to be more productive, differences between the two categories of farms (scheme and non-scheme) were not great and were probably a reflection of better animal husbandry practices and not breed differences. The benefits from the higher goat productivity in scheme farms may be offset by the higher cost of better animal husbandry required due to improved breeding. Some of the local goats (that do not require high animal husbandry measures) may have the potential for reasonable milk production and thus selection for this and other desirable traits can be carried out within these breeds.

Local breeds of goats, together with their crosses to a range of exotic breeds, and pure exotic breeds should be subjected to animal trials under similar management and feeding regimes so as to establish their production potential.

At present, there seems to be limited use of fodder trees in the diets of goats. There is therefore need to determine the effect on growth rates and milk production of incorporation of various levels of fodder trees in the "basal" diets of goats.

Generally, the animal health measures adopted by the farmers seemed adequate to keep away diseases/pests.

There is need to determine the optimum technical and economic performance of small-scale goat farming in the region.

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Table Number of goats in each farm at the start of the monitoring activity

Farm Number	Number of mature goats		Other goats (Weaners, kids, etc.)	
	Female	Male*	Female	Male
Scheme-A				
1	4	1	4	1
2	3	-	2	-
Scheme-B				
3	3	1	1	3
4	3	1	1	-
5	2	-	1	-
Non-scheme				
6	1	-	1	1
7	3	1	2	1
8	2	2	-	1
TOTAL	21	6	12	7

* Only Farm 1 has an exotic Alpine buck. The rest of the farms had local bucks.

Table 2. Comparison of aspects of animal production in scheme and non-scheme farms

Animal Production aspects	Scheme		Non-Scheme
	Crossbreed/Purebred goats	Indigenous goats	Indigenous goats
Feed Resources:			
1. Forage Types;	Napier grass, Sweet potato vines, Banana leaves, *Tithonia diversifolia*, *Trema orientalis*, *Vernonia lasiopus*, *Calliandra calothyrsus*, Avocado leaves, *Triumfetta spp.*, Kikuyu grass, Star grass, Wandering Jew (*Commelina benghalensis*), Banana stems, Bean stover, Maize stover, etc.	Napier grass, Sweet potato vines, Banana leaves, *Tithonia diversifolia*, *Trema orientalis*, *Vernonia lasiopus*, *Calliandra calothyrsus*, Avocado leaves, *Triumfetta spp.*, Kikuyu grass, Star grass, Wandering Jew (*Commelina benghalensis*), Banana stems, Bean stover, Maize stover, etc.	Napier grass, Sweet potato vines, Banana leaves, *Tithonia diversifolia*, *Trema orientalis*, *Vernonia lasiopus*, Wandering Jew, Kales, Banana peelings, Potato peelings, Avocado leaves, *Triumfetta spp.*, Maize stover, Kikuyu grass, Maize stover, *Lantana camara*, etc.
Quantities offered (kg fresh/goat/ day)	6.6	7.2	7.4
2. Concentrate Types;	Dairy Meal, Bran	Dairy Meal, Bran	Dairy Meal
Quantities offered (kg/goat/day)	0.88	0.92	0.80
3. Mineral licks/salts	one of the farmers uses *ad libitum*	*ad libitum*	one of the farmers uses mineral salts
4. Water	*ad libitum*	*ad libitum*	*ad libitum*
Animal Health:			
1. Vaccinations	Contagious Caprine Pleuro Pneumonia (CCPP) vaccine	none	none
2. Tick control	none	one of the farmers sprays	none
3. Internal parasites control	deworming	deworming	none
4. Mastitis control	None	none	none
5. Others	Hoof trimming	Hoof trimming, treatment for eye problems	treatment for eye problems

Table 2 (cont).

Animal Reproduction:			
1. Age at first service (months)	21.75 [17.0 - 26.5]	17.0	12.0
2. Type of buck	Alpine buck	Alpine buck	Local buck
3. Gestation length (days)	146.5	146	147
4. Kidding interval (days)	315	270	nd
5. Average number and weight of kids born per doe per year	One set of twins or one kid; Twins; male (2.5 kg), female (2.3 kg) Single; male (3.0 kg), female (2.5 kg)	One set of twins or one kid; Twins; male (2.0 kg), female (2.0 kg) Single; male (3.5 kg), female (2.0 kg)	One kid or a set of twins; Twins; male (1.75 kg), female (1.75 kg) Single; male (2.75 kg), female (2.0 kg)
Animal Performance:			
1. Milk Production (l/day)	0.875	0.60	0.30
2. Lactation length (days)	125	127.5	107
3. Growth rate of kids (g/day)	93	nd	nd
Mean Manure Production (Yearly):	29 wheelbarrows	33 wheelbarrows	300 wheelbarrows
Socio-economics:			
1. Main labour supply	Mainly wife	Mainly wife	Mainly husband
2. Time spent looking for feeds (hr/day)	1.71	0.99	1.78
3. Time spent looking for feeds (minutes/goat/day)	4.1	2.3	5.1

nd - not determined

Discussions on Paper 7 (Kariuki)

Q. What is the importance of dairy goats in the area as compared to dairy cows?

A. Right now, cow milk is more important than goat milk. However, as the land size becomes smaller due to subdivision, farmers will have problems finding adequate feed resources for dairy cattle. Since there is still demand for milk, there is need to look for alternative production sources.

Q. What are the goats used for? For milk or meat?

A. The impression obtained from the monitoring is that since the number of animals kept is low, the farmers are not commercial-oriented and are keeping the animals mainly as a source of ready cash in case of pressing needs in the family. Milk and meat production are not the main reasons for keeping goats.

Q. Were the scheme farms monitored part of the former Embu Meru Isiolo (EMI) livestock project?

A. No, the scheme farms are part of the Integrated Small Livestock Project (ISLP) working in the high agricultural potential areas of Embu district and other districts in the central highlands.

Q. What were the criteria for choosing the eight farms where monitoring was carried out?

A. We would have liked to use more farms but they were not available. The farms used were selected on the basis of two separate criteria;

1. Those farms keeping Purebred/Crossbred goats.
2. Scheme and Non-scheme farms.

Q. Why are the Scheme farms with indigenous goats feeding more concentrates (0.92 kg/goat/day) than the scheme farms keeping purebred/crossbred goats (0.88 kg/goat/day).

A. Feeding of concentrates (Dairy meal or bran) does not seem to be tied up with production. Even indigenous goats in the non-scheme farms are getting about 0.80 kg concentrate/goat/day and the peak milk production is 0.3 kg/day. Figures from literature indicate that 0.5 kg/day of concentrate is enough for a lactating goat.

Paper 8

Input and output data monitoring at the zero-grazing model farm unit at RRC-Embu: the case of dairy cattle performance on an agroforestry-based feeding system

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Abstract

A study was initiated in October 1994 at the zero-grazing `model' farm unit at the Regional Research Centre, Embu. The aim was to evaluate on a long-term basis, the milk production potential of Guernsey x Ayrshire cows maintained on an agro-forestry based feeding system combining fodder grasses, fodder tree species and herbaceous legumes. Napier grass (*Pennisetum purpureum*) and sweet potato (*Ipomea batatas*) vines formed the main basal diets offered while fodder trees and herbaceous legumes formed the main supplemental diets in place of dairy meal. The supplemental forages included *Calliandra calothyrsus, Sesbania sesban, Gliricidia sepium* and *Leucaena leucocephala*, Mulberry (*Morus alba*), green leaf Desmodium (*Desmodium intortum*), silver leaf Desmodium (*Desmodium uncinatum*) and Tropical Kudzu (*Pueraria phaseoloides*). The feed intake of each ingredient was measured on daily basis. However, the amount of supplemental diet allotted varied from time to time depending on availability. Both the type and level of each diet offered had some influence on the daily milk production. Supplementation with 6 kg fresh Calliandra tended to give similar responses to 2 kg of commercial dairy meal; the yield being higher when other leguminous forages were additionally offered. The results also demonstrated that although Napier should form the bulk of the feed, there may be added advantages of including sweet potato vines to the basal diet if better responses in terms of feed intake and milk production are to be expected. This is especially so at low levels of leguminous forage supplementation or during the dry season when the quality of Napier grass, the main basal forage, is normally poor. The comparative effects of different feed resources on milk production, labour resource use in relation to feed resource utilization and the economic implications of an agroforestry based feeding system were determined.

Introduction

It is acknowledged that the level of milk production under the zero-grazing systems in Kenya remains low due to several factors. Poor nutrition resulting from inadequate feeding both in terms of quantity and quality remains the main factor affecting production (Abate *et al.*, 1990). Napier grass (*Pennisetum purpureum*), the main basal diet offered to the dairy cattle in the small-holder farms, is unable to supply all the required nutrients to support high levels of milk production unless supplemented, despite the expectedly high genetic potential of the dairy animals kept by the farmers in the coffee land use system of Embu. It is generally recommended that lactating cattle be supplemented with commercial concentrate feeds to correct for nutrient deficiencies in the basal diets. However, this is not always achieved by a majority of the farmers due to either high cost, unavailability or uncertified quality of the commercial feeds. It is hypothesised that appreciable levels of animal output could be achieved through the use of locally available feed resources with greater use of multi-purpose fodder tree species. It is also recognized that labour resource availability related to feed resource production and utilization could affect production since available labour on the farms is normally committed to several activities amongst different enterprises. The study reported here was therefore initiated with the objective of monitoring inputs and outputs at a 'model' zero-grazing farm unit at the Regional Research Centre Embu with a view to assessing the implications on the utilization of available labour and lactational performance of zero-grazed cows of integrating an agro-forestry- based feed resource. The main feature of the system was the use throughout the season of different forages and a deliberate avoidance of commercial feeds. The opportunity was also taken to evaluate the economic implications with regard to inputs into and outputs from the system.

Forage Production and Management

The total area of the model unit farm is approximately 1.21 ha out of which only 0.43 ha is under forage crops. Napier grass occupies about 25 percent of total area while the combined area for Sweet potatoes (*Ipomea batatas*), green leaf Desmodium (*Desmodium intortum*), silver leaf Desmodium (*Desmodium uncinatum*) and Tropical Kudzu (*Pueraria phaseoloides*) is about 8 percent. Approximately 50 percent (0.5 ha) of the rest of the land is potential arable land for cultivation of crops or additional forage. Prior to April 1994, the main feed resource at the zero-grazing unit was Napier grass which occupied less than 0.1 ha and in most cases additional Napier grass had to be obtained from other places in order to provide enough bulk for the two cows at the farm unit. Part of the expansion made was to increase the area under Napier to cover about 0.35 ha and to incorporate hedgerows of Calliandra (*Calliandra calothyrsus*) within the Napier grass plot. Additional hedgerows of Calliandra and some Mulberry (*Morus alba*) were planted along the external or internal boundaries thus occupying niches that would normally not be used for cropping purposes. The other forage species planted included dual purpose sweet potatoes (var. Musinya and ex-Mukurweini), Tropical Kudzu and Silver and green leaf varieties of Desmodium. Additional forages that were planted much later include Gliricidia (*Gliricidia sepium*), Giant Panicum (*Panicum maximum*) and Cassava (*Manihot esculenta*). The area or number of trees for the respective forages at the zero-grazing unit is given in Table 1.

Table 1. Forage Resource at the Zero-grazing Farm unit of RRC Embu

Forage type	Area(m^2)/ No. of yield trees	Total DM (kg)[a] per cut	Expected number of cuts per yr.	Annual DM yield (kg)
Napier grass	3500 m^2	9450	6	56700
Calliandra	1200 trees	840	6	5040
Sesbania	30 trees	12	5	60
Gliricidia	26 trees	19	3	54
Mulberry	105 trees	42	5	210
Sweet potato	590 m^2	590	3	1770
Desmodium	207 m^2	310	6	1860
Tropical Kudzu	168 m^2	168	4	672
Total				66366

[a] Based on DM values given in Appendix Table 2.

Routine management of the fodder trees entailed cutting back to a stubble height of 1m to avoid overgrowth. Routine weeding of all the forages was done although considerably less labour was required in weeding both the fodder trees and herbaceous legumes since these forages appeared to smother most of the weeds growing under them, especially where two-row hedge pattern was maintained for the trees. Napier grass was cut after attaining a height of 2 meters above ground generally after every 6-8 weeks. It was cut to a height of 15-20 cm above ground. Slurry, comprising of cow dung, urine and water for cleaning the shed was routinely collected in pits dug next to the shed. It was subsequently applied between Napier grass rows mainly after the weeding. Part of the slurry was also applied to the fodder trees.

Sampling of the Napier grass, herbaceous legumes and sweet potato foliage for fresh weights was done using a 1m x 1m quadrat, after which sub-samples of the foliage were taken and oven dried (60^0 ; 48 hrs) for dry-matter yield determination (see Appendix Table 2). Yield determination for fodder trees involved pruning of foliage from a 1m row-length or from individual trees.

Animals and Feeding Management

Two Guernsey x Ayrshire cows, No.H76 (Waithera) and No.H87 (Wagathoni) at their 6th and 4th lactation, respectively were initially held at the zero-grazing unit for which the first records on inputs and outputs were taken. The respective calving dates for the two cows were 25 September 1994 and 7 October 1994. Due to an unexplained skin disorder, Waithera was replaced by another cow, No. H86 (Wanduati) on 10 March 1995, whose calving date was 22 April 1994. Record taking on daily milk output started on 26 September 1994 immediately after calving down of Waithera. However, records on the types and levels of each feed on offer started on 8 October 1994 and has since continued on a daily basis.

The amounts and type of each supplemental forage varied considerably, depending on what was available. Similarly, the basal rations were varied but largely comprised of Napier grass and sweet potato vines; these were offered at levels that would ensure *ad-libitum* intakes. Napier grass and all the other forages were chopped before feeding. Both the amounts of the basal and individual feed ingredients offered and that refused were measured daily so that feed intake could be calculated. Similarly, daily milk yields were recorded daily and the amounts of water taken by the cows was also recorded. Cows were milked twice daily (7:00 hrs and 15:00 hrs).

After calving down of Wagathoni and Waithera, their calves were reared following the recommended standards, initially starting with colostrum and later on calves continued receiving normal milk. Although milk intake formed the bulk of the feed offered to the calves, an assortment of forages was also provided; feeding of forages started as early as two weeks after birth. Maximum use of available forages was made in feeding the calves especially the leguminous types that are relatively high in protein with the aim of weaning at less than the 14 weeks conventionally recommended.

Labour Use in Forage Utilization

A record of the time taken to perform the various activities related to forage utilization was maintained on daily basis. Of particular interest was the time taken to harvest, chop and offer the various forages to the animals.

Results and Discussion

Feed Intake

Low intake of digestible nutrients is one of the factors that can affect animal performance (Agricultural Research Council, 1980). An initial evaluation of the feed intake levels from offering a variety of forages was therefore made. Table 2 shows the average feed intakes for both the basal diets and the supplements for each feeding regime determined during selected days over a six month period.

Table 2. Mean Dry-matter Intakes of Cows at the Zero-grazing Unit Offered Different Forages.

Feeding duration (days)	Supplement (kg fresh/day)	Basal intake (kg fresh/day)	Basal DM intake (kg/day)[a]	Total DM intake (kg/d)
16 (Oct.1994)	4 kg Dairy meal	39 kg Napier	7.0	8.9
9 (Oct 1994)	2 kg Call. 1 kg Desm.	34 kg Napier 12 kg SPV	6.1 1.9	
8 (Nov 1994)	4 kg Call. 3 kg Desm.	32 kg Napier 12 kg SPV	5.8 1.9	
15 (Nov 1994)	3 kg Desm.	39 kg Napier 20 kg SPV	7.0 3.2	
23 (Dec 1994)	3 kg Desm. 1 kg Call.	37 kg Napier 20 kg SPV	8.1 3.2	
30 (Dec 94/Jan 95)	3 kg T/Kudzu 1 kg Desm.	37 kg Napier 20 kg SPV	8.1 3.2	12.3
6 (Jan 1995)	3 kg Desm. 1 kg Call.	37 kg Napier 20 kg SPV	8.1 3.2	10.1
15 (Feb 1995)	3 kg Desm.	46 kg Napier	10.1	10.9
7 (Feb 1995)	1 kg Call.	47 kg Napier 4 kg Mulberry	10.3 1.1	11.4
8 (Feb.1995)	1 kg Call. 2 kg Sesbania	50 kg Napier	11.0 0.5	11.5
9 (March 1995)	1 kg Call. 1 kg Sesbania	50 kg Napier	11.0	11.3

[a]Estimated mean DM (%) levels of: Napier grass, 22 (dry season) and 18 (wet season); Calliandra, 28; Desmodium, 27; T/Kudzu, 24; Sesbania, 25; Sweet potato vines, 16; *Morus alba* (Mulberry), 28 (RRC Embu laboratory. determinations).

It is observed from Table 2 that daily Napier grass DM intakes varied considerably ranging from 5.8 to 11.0 kg. Similarly, total DM intakes were variable but largely depended on both the amounts of supplemental and basal feed offered. However, intakes were generally higher during the dry season than during the wet season. This is expected since the DM content of the forages are normally higher in the dry season than during the wet seasons. The relatively high moisture contents of forages especially during lush growth does not allow the animal to ingest enough bulk to satisfy its daily nutrient requirements. Although in theory Napier grass can provide adequate bulk, its generally low nutritive value during the dry seasons could limit total feed intake unless supplemented with high quality diets. It is acknowledged that the importance of the supplemental forages, especially fodder trees, in improving feed intakes is mainly through an enhanced efficiency in the utilization of the main basal diet. Supplementation of Napier grass or any other basal forage is crucial, especially so during the dry seasons, since this will allow the cow to ingest more nutritious material which could subsequently improve milk yield. The responses in terms of milk yield to different forage supplements are discussed later.

Milk Output

General Lactational Performance

Generally, milk yields for Wagathoni and Waithera were high just after calving down. Although this is expected for cows at early stages of lactation, the pattern did not appear to reflect the normal trend for which yields are supposed to go up to a peak at about 3-4 weeks before declining as the stage of lactation advances. It is however known that the trend in the lactational curve could be influenced by several factors which include the genetic potential of the animal. The nutritional status of the forages, which is further influenced by seasonal variations, plays a major role in influencing the general decline in milk yield as stage of lactation advances and therefore the overall lactational yield. It is unlikely that Napier grass was wholly responsible for the high yields given the fact that Napier grass during the wet period (October) and the additional forage supplements would have provided all the required nutrients for the level of yield observed. Total DM intakes in early lactation (Table 2) were also lower than expected for the cows. It is known that cows at early lactation are capable of mobilizing their body reserves for milk synthesis (ARC, 1980; McDonald *et al.*, 1981). This could probably explain the relatively high yields during this period. However, subsequent yields, though variable for all the three cows, may have responded to seasonal weather effects and the types and levels of both the supplemental and basal diets offered.

Generally, milk yield peaks coincided with the wet seasons (Oct-Nov and March-May) with depressions occurring during the dry seasons (Feb and July-Sept). Although this general trend is expected, and was fairly similar among the three cows, the magnitude of change in the diurnal responses for the three cows could be attributed to the nutrient supply from the supplements which further depended on the types and amounts of supplemental diets offered at different periods.

The total lactational yield for Wagathoni over the entire lactation period of 450 days was 2942 kg. However, the daily yield averaged over a 300-day period was about 7.5 kg which was generally lower than the average of about 8.3 kg reported for the region, although the latter is achieved with concentrate supplementation at a daily rate of 2 kg per head (Ministry of Agriculture, Livestock Development and Marketing Report, 1992). Milk yield levels of up to 9.5 kg/hd also been observed when cows subsisted on basal diet of Napier grass only and 4 kg dairy meal supplementation (Kiruiro *et al.*, 1980). The diets in the latter study were, however, evaluated over a short-term period and with cows generally in early stages of lactation. Other reports for studies carried out within farms in the coffee land-use system of Embu District indicate that up to 11.4 kg of milk could be realized from cows in their 3rd-5th months of lactation when fresh Calliandra is offered in addition to the normal commercial concentrate levels (2 kg/hd/day) offered by a majority of farmers; the yield effects of the Calliandra and dairy meal being additive (Paterson *et al.*, 1996). Similar yield responses for stall-fed cows have been reported for farms in Kiambu District under intensive management with cows receiving concentrate and mineral supplementation in addition to main basal diet largely made up of Napier grass (Abate *et al.*, 1990).

It is known that lack of mineral salt supplementation to lactating cows could affect production; Ca and P may be necessary especially where animals have the genetic potential to produce milk levels of about 10 kg or over per day (Abate *et al.*, 1990). Whether lack of mineral supplementation at the RRC Embu farm unit could have resulted in the cows not fully expressing their genetic potential is not clear although it had been assumed that forages would provide reasonable amounts of minerals. Browse tree species are generally rich in mineral concentration especially for Ca, P, K and Mg compared to grasses (de Leeuw, 1988) but are low in Na that could have negative effects on milk production (Paterson, R.T., personal communication). However, the assumption was that the cows at the unit farm would meet most of their mineral requirements from the forages. Although a determination of the chemical composition of the forages was not made, it is also recognized that an imbalance between protein and energy could result in poor utilization of the available protein from the forages for milk synthesis. It is planned to assess during subsequent lactations for the cows at the RRC Embu unit farm, the effects of including cassava tuber-based diets on milk production utilizing the cassava already established there.

The lactational performance of the cows at the unit farm highlight the important contribution that high quality feed, especially leguminous forages, can make to achieving reasonable performance and improvement of the utilization of the basal diets. Fodder species such as Calliandra ensure availability of good quality fodder both during the wet and dry seasons. Forage supplements not only provide additional nutrients but also improve the efficiency in the utilization of the basal diets by the thus utilizing the available protein for milk production in a cost-effective way. Based on the results so far obtained, it is concluded that feeding locally grown forages, especially leguminous fodder shrubs, may not only be biologically efficient in improving performance but could also be economical.

Although more use has been made of the fodder trees and herbaceous legumes to provide the bulk of the supplement to the basal diet, their potential effects towards milk production by the animals is not well understood but would to a large extent relate to the supply of protein. It is, however, recognized that although some forages such as Desmodium and Calliandra are high in protein content (above 200 g/kg DM), they are also found to contain high levels of condensed tannin (Kaitho *et al.*, 1993; Palmer and Schlink, 1992) which could have adverse effects on the utilization and therefore availability of protein to the animal (Reed and Soller, 1987). Nevertheless, feeding of these forages, as the milk yield data indicate, had a definite positive effect on milk production. Thus feeding of several forages together is considered here to be superior approach rather than relying on Napier grass alone since it could allow the animal to take advantage of the critical nutrients both in terms of their concentration and availability.

It is, however, recommended that studies be carried out in future with the aim of assessing what actually contributes to the milk responses since different feeds vary in quality. A determination of the quality parameters of different feed resources will be necessary so that responses can better be related to feed quality. Recommendations can then be made on feed allocation (optimum combination) at farm level necessary to achieve a given level of milk production or to meet specific requirements of the cow. It is further recommended that although at present more emphasis is being given to Calliandra, the replacement potential over commercial meals and therefore optimal rates of supplementation of other shrubs for which agronomic potential in the region is already established should be evaluated. These range from the indigenous *Trema orientalis*, to the naturalized Mulberry and other exotic species such as Gliricidia.

Diurnal Responses to Feed

Data extracted for Wagathoni (Appendix Table 1) demonstrate the range of diurnal responses in milk yield to different feeds. The major supplement to cows was Calliandra for which the main effects upon milk production could be attributed That cows certainly responded to Calliandra supplementation is evident from the data in Appendix Table 1, since the response in milk yield to a daily supplement of 6 kg fresh Calliandra was similar to that of 2 kg dairy meal observed after the Calliandra was withdrawn according to the feeding regime adopted between 15 March 1994 and 3 May 1994 (day 160-209 of lactation). The main basal diet during this period remained Napier grass and sweet potato vines offered at a daily rate of 39 kg and 10 kg fresh material, respectively. The mean daily milk yields obtained from Calliandra and dairy meal supplement were 8.2 and 8.7 kg, respectively. Based on these results, it would appear that dairy meal could be replaced with Calliandra without adversely affecting milk production. The results further suggest that 2 kg of dairy meal could be replaced by 6 kg fresh Calliandra. The replacement potential of fresh Calliandra over dairy meal of 3:1 had previously been suggested after a short-term on-farm feed evaluation study involving 15 cows on 12 farms within Embu (Paterson *et al.*, 1996).

Yield data further indicate that there were generally better responses when the level of Calliandra was increased as shown by comparing milk responses between days 110-116 (1 kg Calliandra), 365-391 (3 kg Calliandra) and 33-41 (4 kg Calliandra). It was also evident that the responses to Calliandra both at high and low rates of supplementation were further improved when Desmodium, tropical Kudzu or Sesbania were additionally offered as yield values for days 80-110, 131-155 and 352-365 indicate. Although responses to similar rates of the different legumes additional to Calliandra were not discernible, feeding of Tropical Kudzu (day 80-110;) and Sesbania (day 209-212) appeared to give higher responses than Desmodium. In fact the highest daily milk yield observed during the entire lactation (8.8 kg) was obtained with a mixture of 3 kg Calliandra and 2 kg Sesbania from a short-term observation (day 210-212). The foregoing results tend to suggest that there are additive effects by combining the various forages together. This emphasizes the need for complimentarity between feed resources if better results are to be expected. Despite the responses to the several forage supplements, the effects upon milk yield of including or excluding sweet potato vines were rather dramatic. In fact withdrawal of sweet potato vines due to seasonal shortages between January to March as observed for days 110-146 and 309-328 (Appendix Table 1) resulted in a milk yield drop of about 32 percent in the former period increasing again by about 20 percent when sweet potato vines were reintroduced (mid-March; from day 155). When Napier grass was substituted with up to 60 percent of maize stover (due to seasonal availability of the latter in August-September; day 328-341) and offered with low levels of leguminous forages, milk yield responses turned out to be very poor.

It is envisaged that where seasonal shortages of either Napier grass or sweet potato vines occur or where crop residues such as maize stover are available in large quantities, better responses may be expected with higher levels of inclusion of fodder tree foliage or sweet potato vines. Based on observations made at the RRC unit farm, Calliandra, for instance, continued to provide fresh foliage even during the dry seasons of the year as opposed to the herbaceous legumes which succumbed to the relatively dry and cold weather conditions (July-Sept). The results from the RRC unit farm strongly point to the need to have adequate amounts of Calliandra on the farms in order to provide a daily requirements of at least 6 kg per lactating cow to take advantage of the incremental effects of supplementation on milk yield. Sesbania and Gliricidia confer similar quality characteristics to Calliandra and could also be fully exploited although Sesbania does not withstand frequent cutting as observed at the unit farm and has relatively low biomass production capacity.

Feed Requirements

Napier grass constituted about 65 percent of the total bulk provided to the cows (Table 2). It was observed that the mean daily dry-matter intake for Napier grass especially during supplementation with dairy meal was 8.9 kg (Table 2) this being below the recommended levels of about 3 percent per kg body weight assuming a 400 kg body weight for the cows at the zero-grazing unit. However, with incorporation of other forages, DM intake of Napier grass was generally reduced although total DM intakes were increased with up to 12.3 kg DM being recorded. It was apparent that provision of other forages may have improved the efficiency with which the grass was utilized. Intakes of Napier grass appeared to be higher during the dry season period (Feb/March).

It is generally recommended by the Ministry of Agriculture, Livestock Development and Marketing that to sustain the roughage requirements of two zero-grazed cows for the whole year, about 0.4 ha (1.0 acre) of well managed Napier grass is needed, with the grass meeting on average up to 75 percent of the bulk eaten by the cows, while the rest should be derived from other feed resources. It must, however, be recognized that during the dry and cold seasons in the Embu region and indeed several other parts of the country, Napier grass growth and therefore effective dry matter yield could be much less than normal. This is also aggravated by the low level of management of Napier grass production by the majority of farmers. Based on DM yield estimates given in Table 1, the annual DM yield at the unit farm of RRC Embu averaged over all the forages amounted to 66 tonnes, with about 12 percent consisting of leguminous forages of high quality; Calliandra alone contributed about 8 percent. With a mean total daily DM intake of 12.1 kg per cow during forage supplementation based on data in Table 2, then the annual total DM requirement is estimated at 8800 kg (8.8 tonnes) for two cows. It could therefore be argued that with the level of forage output at the unit farm, the requirements of more than 2 livestock units (2 mature cows) and their young followers could be met based on the total area under forage. It is also envisaged that a high density of arable farming could be possible utilizing up to 75 percent of total available land of 1.21 ha.

It should therefore be appreciated that the integration of other feed resources, in particular, fodder trees has several advantages which include a sustained production of extra forage of better quality without necessarily demanding additional arable land. Thus more land could be made available for the farmer to grow either cash or subsistence crops and some additional forages such as herbaceous legumes and sweet potatoes in a more or less similar pattern to that demonstrated at the unit farm of RRC Embu. A high level of management of all the forages is necessary in order to achieve optimal performance. This includes timely weeding, appropriate harvesting/cutting practices and application of cow slurry especially to Napier grass. Under an improved local feed resource base, Napier grass is likely to form even less than 65 percent of the bulk required which could be of socio-economic importance.

Considering the limited fodder production capacity of the farmers in Embu region, then foliage from fodder trees should be seen as a remedy towards meeting the short-fall in feed availability with potential for improving or stabilizing milk production. It is recommended that farmers plant sufficient fodder trees utilizing the available non-cropped niches in order to provide the extra fodder. Assuming a daily requirement of about 10-12 kg fresh Calliandra (2.8-3.4 kg DM) for the two cows at the zero-grazing unit, including that needed to replace about 2 kg dairy meal over a 300-day lactation, a total of 3.7-4.4 tonnes fresh material (1.04 -1.2 tonnes DM) per annum is required. Harvest data taken at the model farm indicated that a metre length of single row Calliandra hedge gives on average 5 kg of fresh foliage or 1.4 kg dry matter; each metre contains two plants. Thus an estimated linear distance of 750-900 m of single hedge (or about 1500 to 1800 trees) may be needed to meet the annual requirement of the two cows.

The current linear row length of a single Calliandra hedge planted at RRC Embu zero-grazing unit is approximately 600 m which according to these calculations would be considered insufficient to meet the annual requirements of the two cows. However, observations at the farm unit tend to suggest that 5 to 6 weeks cutting interval may be needed in order to attain the desired height of cutting Calliandra during the wet seasons while 8 weeks or more may be taken during the dry seasons. Thus, assuming on average 6 cuts per annum, then the current row length of Calliandra at the farm unit may be considered sufficient to meet the annual requirements of the two cows at least within the lactating period. Indeed, the feed resource has not been restricted to Calliandra alone since other complimentary forages grown have been exploited. The linear row length of Calliandra can be reduced by approximately a half without affecting biomass production by planting Calliandra in double hedgerows. On a typical farm, at least within the coffee land use system, Calliandra and the other forage shrubs can be planted along perimeter boundaries to the farm, on contour bands, within homesteads, within existing Napier grass plots and any other available niches not suited to cropping.

However, in order to fully appreciate the feed supply potential of the different fodder tree species, there will be need to determine yield of different forage species on a year-round basis and to establish appropriate wet and dry season management practices to increase both herbage quantity and quality. In addition, there will be need to establish the suitability of the different forages for their integration with food crops to improve on overall feed supply without affecting crop yields.

Labour Resource Utilization

It was found that the time taken in harvesting, transportation, chopping and feeding of the various forages planted at the zero-grazing unit would vary depending on the amounts of forage available or milk produced by the animals. Table 3 shows how the available labour was utilized amongst several routine activities related to the utilization of the main forages offered to the cows during peak forage production.

Table 3. Mean Time Spent (hrs/d) in Routine Activities Involving Forage Utilization

Time spent/ activity(hrs)	Napier grass (120 kg/d)	Calliandra (10 kg/d)	Sweet potato vines (20 kg/d)	Desmodium (10 kg/d)
Harvesting	0.60	0.25	0.18	0.18
Transportation	0.28	0.08	0.07	0.03
Chopping	0.82	0.15	0.15	0.12
Total/forage	1.70	0.48	0.40	0.33
Feeding[a]				
Milking[b]				
Cleaning shed[c]				

[a] Time taken to feed a mixture of all the forages
[b] Average for two cows at high (11-16 kg) and Medium (6-10 kg) and Low (3-5 kg) milk production periods of 28, 18 and 10 minutes, respectively.
[c] Includes time required to remove left-overs and wash off slurry

Data from Table 3 indicate that a total of 4.59 man-hrs of labour could be devoted to routine activities involving forage utilization out of which 2.91 man-hrs are spent on forage preparation while the rest (1.68 man-hrs) are used up in feeding, milking and cleaning the shed. No other activities with a direct focus on labour were considered. The proportion of total time that is allocated to the harvesting of the fodder trees is about 10 percent, which was generally comparable to that spent on the herbaceous legumes and sweet potato vines, while that for Napier grass is about 37 percent. The results would tend to suggest that a commitment of that order for the fodder trees utilization is unlikely to be seen as extra labour at farm level that could have significant interference with other activities undertaken by farmers in the Embu region even during peak labour demand periods. The results from this study nevertheless suggest that labour availability in general could be an important constraint to milk production. Upwards of about 6 man-hrs may be required to manage a two-cow dairy production enterprise taking into consideration labour engaged in all routine activities such as milking, feeding calves, cleaning utensils, and occasional application of slurry to Napier grass and weeding of forages.

It is recognized that in a dairy production enterprise farmers utilize several inputs which are necessary in the production of milk. These include forage planting materials, fertilizers and labour. According to Amir and Knipscheer (1989), farmers will choose the level of each input that produces the quantity and quality of product that best satisfies their goal. Presently there is an unsatisfied demand, coupled with a lucrative price for milk and its products, at least for the Embu region, which has given great impetus to farmers to expand on dairy production; there is currently a proliferation of stall-feeding (zero-grazing) dairy production units in the high and low potential areas in the region. Farmers are therefore likely to devote a significant amount of the available labour to improve on milk production. This points to the need to have a well developed feed resource base backed by availability of other production factors, mainly labour. If the labour resource scenario at the RRC Embu farm unit is anything to go by, then farmers in the region are expected to optimally exploit the feed potential of agro-forestry based feed resources towards maximizing the production of milk if returns from milk are certain to improve. However, there will be need to better understand the role of gender and its implications at farm level in so far as forage production and utilization is concerned.

Economic assessment

It was not the intention of this study to carry out an in-depth economic analysis of the entire zero-grazing production system but rather to show the economic returns that can be expected based on the data covering the average milk output by exploiting agro-forestry feed resources. As such consideration is given to simple gross margin analysis taking into account gross revenue from milk sales and variable costs covering labour, inputs such as drugs, fertilizer, acaricides and drenches and ignores capital costs (e.g. establishment of the forages or cost of animals and the zero-grazing structure and the associated depreciation costs). The cost of utilizing the forages including fodder trees is assumed to be absorbed in the regular hired labour since this mainly entails cost of weeding, harvesting, transportation and feeding the forage. A simple gross margin calculation comparing the forage based supplement at the unit farm with one based on commercial dairy meal is given in Table 4.

Table 4. Comparative Gross Returns Based on Forage or Commercial Supplements.

Item	Cost (KShs.)	
	Forage based	Dairy meal
Labour: 365 man-days @ 50/= per m.d[a]	18250/=	18250/=
Fertilizer: 2 bags CAN @ 1300/= per bag	2600/=	2600/=
Spraying: 2.5mls Triatix per week x 52 weeks @ 1.80 per ml	234/=	234/=
Drenching: 150ml Nilzan x 4 applications/year @ 1.20 per ml	720/=	
Sundries: (e.g. detergents, drugs,)	1000/=	
Concentrate and minerals:		7500/=
Total variable costs:	22804/=	30304/=
Gross Revenue (Price of 14/= per litre milk as per May 1996):	34860/=[b]	34440/=[c]
Gross margin (Gross revenue less variable costs)	11856/=	7496/=
Gross margin/yr for two cows (assuming equal performance)	23712/=	14992/=
Monthly returns per cow (over a 10-month period)	1186/=	750/=

[a] Average daily rate to undertake all activities including those shown in Table 3.
[b] Based on 6 kg Calliandra per day supplementation with mean daily milk yield of 8.3 kg for a 300-day lactation period
[c] Based on an estimated milk yield for the region of 9.0 kg with 2 kg dairy meal and about 150 g/hd/day mineral supplementation over a 300-day lactation period.

In order to make any meaningful deductions, other sets of data may require collection at farm level taking into consideration the socio-economic and bio-physical factors likely to influence forage production and utilization and therefore the returns from the dairy enterprise after the integration of an agro-forestry based feeding system. However, even with the limited data collected at the RRC Embu unit farm, it would appear from the outset that comparatively better returns are obtained from the dairy enterprise by maximizing use of quality forage supplements grown on the farm than reliance on dairy meal. It is generally observed that the average daily milk yield per head in the which assumes the farmer employs optimal management of the Napier grass basal forage and maximizes use of other forages. Inadequacy and low management of available forages is the main factor that culminates in low milk production. It can be concluded that reliance on home-grown forages that has hitherto not been part of the forage production system of the local farmers is likely to be of economic importance considering that the cost of general maintenance and management skills to sustain productivity of the forages demonstrated in the study reported here, particularly for Calliandra, may be low and the cost of dairy meal is likely to escalate.

It must be appreciated that apart from the benefits from milk sales, additional benefits can be realized from the use of more high quality cow manure or slurry in place of fertilizers in providing nutrients to boost biomass yield in Napier grass or food crops. Leguminous fodder shrubs planted together with Napier grass especially along contour bands could stablise soils and prevent soil and water run-off thereby reducing nutrient losses. The legume also has potential of improving soil nitrogen status through nitrogen fixation which could enhance yield of the companion forage.

Calving Interval

Breeding records show that Wagathoni and Waithera previously calved down on 25 September 1994 and 7 October 1994 respectively. Only Wagathoni has so far completed a full lactation as she calved down again on 22 April 1996, resulting in a calving interval of 450 days. Waithera is expected to calve down in early June 1996. It is recognized that cow fertility and therefore its ability to come on heat depends very much on the mineral status of the diets on offer. It is not clear whether in the absence of any external mineral supplements the mineral status of the forages offered could have affected the reproductive efficiency of Wagathoni. There may be need to evaluate the effects of forage supplementation on the mineral nutrition both in terms of concentration and availability to the animals especially where high levels of mixed forages are offered. Management aspects, however, cannot be overemphasized. Wagathoni continued to be milked long after the expected lactation period of about 300 days as she continued to respond well to the diets. This could also have influenced reconception.

Calf performance

After calving down of Wagathoni and Waithera, their calves were reared following the recommended standards initially starting with colostrum and later on normal milk. One of the calves with an initial birth weight of 32 kg was weaned after 11 weeks of age having attained a body weight of 66 kg without the use of early weaner pellets as recommended. Total milk consumption by the calf over this period was 296.5 litres. Feeding of good quality forages could have contributed to the reasonably good growth of the calf. It was observed that calves cherished a mixture of sweet potato vines, Calliandra, Sesbania and Mulberry; foliage from Sesbania and Mulberry trees was very much preferred. Research at National Animal Husbandry Research Centre, Naivasha indicate that it is possible to wean calves early using sweet potato foliage. Feedings trial involving heifers carried out at RRC Embu have shown the superiority of Mulberry in improving dry-matter intake of Napier grass basal diets and growth performance over other tree fodder species which include Calliandra and Leucaena. Observations at the zero-grazing unit suggest that foliage from Mulberry trees could have potential as an early weaner diet for the calves in view of the observed high palatability; it is also reportedly high in organic matter digestibility (over 80 percent; Thijssen *et al.*, 1993). It is suggested that Mulberry plants, traditionally not used by farmers for dairy cattle feeding, could form an important diet for young calves, while more use could be made of other fodder tree species with high biomass productivity in feeding lactating cattle.

Conclusions

In the present economic environment in the region where the cost of commercial dairy meal is high, it can be concluded that complimentarity in feed resource production and utilization at farm level with greater attention to fodder tree species, may be the most efficacious approach to increasing returns to small-holder farmers interested in maximizing productivity per unit of land and labour. The feed supply of the model farm unit demonstrated that more intensive dairy production was possible than is currently practiced by the small-holder farmers in the region, based on a variety of forages especially fodder trees. The replacement effect of Calliandra over dairy meal could be of major significance particularly for the Embu region since dairy meal use is widespread and the need to reduce costs of supplementation is also appreciated by the farmers. It is envisaged that a high density of forage output per hectare is feasible even with high density of arable farming. Data generated on the feed resources provides valuable information on which to advise farmers on the expected responses to different practical options to suit their farms depending on the labour and land resource availability. However, careful monitoring of the input and outputs taking a holistic view of the actual small-holder farm situation may be necessary to elucidate socio-economic and bio-physical factors that could influence efficient production and utilization of the range of forages discussed here. Overall, the lactational performance of the animals shows promise as the basis for a sustainable feeding system appropriate to small-holder farmers in the region.

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Appendix Table 1. Milk Production Responses to Different Feeds For Cow No. H87 (Wagathoni) over the Whole Lactation Period

Date[a]	Day lact.	Feed type: Supplement[b]	Feed type: Basal Forage[c]	Milk Yield (kg): Total	Milk Yield (kg): Mean
8/10/94	1	3kg Dairy meal	Napier alone	-	
31/10/94	24	2kg Call. + 1kg Desm.	Napier alone	261.6	10.9
9/11/94	33	4kg Call. + 3kg Desm	Napier + 6 kg SPV	91.9	10.2
17/11/94	41	3kg Desm. (No Call.)	Napier + 10 kg SPV	66.5	8.3
2/12/94	56	3kg Call. + 1kg Desm.	Napier + 10kg SPV	118.5	7.9
25/12/94	80	1kg Call + 3kg T/Kudzu	Napier + 10kg SPV	161.5	7.5
24/1/95	110	1kg Call. + 3kg Desm	Napier + 10 kg SPV	251	8.4
30/1/95	116	1kg Call. + 3kg Desm	Napier alone	43,5	7.3
11/2/95	128	3kg Desm.	Napier alone	66.5	5.5
14/2/95	131	1kg Call.	Napier alone	13.0	4.3
1/3/94	146	1kg Call. + 1 kg Sesb.	Napier alone	71.0	4.8
10/3/94	155	1kg Call. + 1kg Sesb.	Napier + 10kg SPV	49.0	5.4
15/3/95	160	2kg Dairy meal	Napier + 10kg SPV	30.5	6.1
10/4/95	186	6kg Call.	Napier + 10kg SPV	227.0	8.7
3/5/95	209	3kg Call. + 2kg Sesb.	Napier + 10kg SPV	167.5	8.2
7/5/95	212	3kg Call.+1kg Sesb + 2.5kg Leuc.hay	Napier + 10kg SPV	26.5	8.8
17/5/95	223	3kg Call. + 1kg Sesb.	Napier + 10kg SPV	62.0	7.5
25/6/95	262	2kg Desm.	Napier + 10kg SPV	243.0	6.2
3/7/95	270	2kg Dairy meal	Napier + Pastures	33.7	4.2
11/8/95	309	3kg Leuc. hay + wheat bran*	Napier alone	208.6	5.8
18/8/95	316	3kg Call.*	Napier alone	41.0	5.9
30/8/95	328	3kg Call.*	Napier + 60 kg Maize stover	56.0	4.7
12/9/95	341	3kg Call+ 2kg Mulb.+ 3kg Sesb.	Napier + 60 kg Maize stover	57.5	4.7
18/9/95	347	3kg Call + 6kg Sesb.	Napier + 10kg SPV	30.5	5.1
23/9/95	352	3kg Call.	Napier + 10 kg SPV	27.5	5.5
6/10/95	365	3kg Call. + 3kg Desm. + 10 kg T. Kudzu	Napier + 10 kg SPV	83.5	6.4
20/10/95	379	3kg Call. + 3kg Desm.	Napier + 10kg SPV	100.0	7.7
26/10/95	383	3kg Call. + 3kg Desm.	Napier + 7kg Giant Panicum	59.0	7.4
3/11/95	391	3kg Call. + 3kg Desm.	Napier + 4kg Mulberry	51.5	6.4
11/11/95	399	3kg Call. + 3kg Desm. + 2.5kg Sesb.	Napier + 2.5 kg SPV	51.5	6.4
17/11/95	405	3kg Call. + 3kg Desm.	Napier + 10kg SPV	32.5	5.4
7/12/95	430	2kg Dairy meal	Napier + 10kg SPV	73.0	3.7
18/12/95	441	2kk Call. + 1kg Desm.	Napier + 10kg SPV	29.0	2.7
20/12/95	443	3 kg Call.+ 3kg Desm.	Napier + 10kg SPV	3.5	1.8
29/12/95[d]	451	3kg Call.	Napier + 10kg Giant Panicum	8.5	1.1

[a] Each date marks start of feeding of specified diets up to the next date that follows.
[b] Supplements offered individually at time of milking unless specified.
[c] Napier fresh matter intake per day over the whole range of feeding was approx. 45 kg at 20% DM (i.e. 9 kg DM).
[d] Cow dried off previous date but continued to receive variable diets up to calving date (22 April 1996).
* Supplements mixed with basal diet in feed trough.

Appendix Table 2. Dry-matter (DM) Values for Forages Planted at the Zero-grazing Model Unit Farm of RRC Embu

Forage type	% DM[a]	DM yield/metre or tree plant
Napier grass	18 (wet season; young) 22 (dry season; old)	2.7 (mean)
Calliandra	28	
Gliricidia	29	0.3
Sesbania	25	0.4
Mulberry	28	0.4
Sweet potato	16	.0
Desmodium	27	
Tropical Kudzu	24	1.0
Dairy meal	62	

[a]Oven-dried samples at 60°C for 48 hrs

Discussions on Paper 8 (Kiruiro)

Q. What was the basis of feed type supplementation and change?

A. An integrated feed regime was being adopted for which cows would be fed on what was available at any given period. Levels of feed were therefore not predetermined in relation to milk yield.

Q. How would you determine the carry-over effect for each feed type?

A. This was not considered necessary as interest was on the overall lactational yield. There were, however, definite effects where a particular diet was offered over a long period.

Q. Why the choice of 6 kg of calliandra to supplement dairy cows?

A. This level was predetermined on the basis of Crude Protein equivalence in relation to normal dairy meal supplementation level offered by farmers (2 kg/cow/day).

Q. There is a problem of seeding in calliandra. What is research doing about this?

A. Calliandra does have a complex seeding problem. The flower morphology precludes insect pollination allowing bats to be the primary pollinators, more so because the most receptive time is at night. No specific research is on-going but increasing the size of the calliandra seed orchard is likely to attract adequate numbers of pollinators (bats). The gradual pod maturity requires constant harvesting to minimize shattering losses.

Q. What is the pattern of forage production in calliandra? Can it be used during the dry season when there is scarcity of animal feeds?

A. Dry matter (herbage) yield of calliandra does not markedly drop during the dry season and can therefore provide year-round feed. Current studies indicate that calliandra production is not affected by the dry season probably because of the deep root system. However, cold weather lowers dry matter yields.

Q. Do you have adequate amounts of IFTS for phase II feeding studies?

A. Yes, on-station. With time, this will be extended to on-farm conditions.

Paper 9.

Calliandra in Dairy Production

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Abstract

During the course of the animal nutrition sub-project of the National Agroforestry Research Project, two large on-farm experiments and two smaller on-station observation trials were conducted to evaluate the effects of feeding fresh fodder of *Calliandra calothyrsus* to dairy cows and heifers. In the on-farm work, it was shown that 3 kg of fresh calliandra had the same effect on milk yields as 1 kg of additional dairy meal with 16% crude protein, while stimulating increased butterfat content of the milk. The effects of the two supplements showed no interaction, indicating that calliandra could be used with equal efficiency, either in addition to dairy meal to increase productivity, or to replace it, in order to reduce the cost of milk production. One on-station trial confirmed the on-farm replacement value of calliandra fodder, while the other showed that calliandra could be used to good effect for the long-term (10 months to date) supplementation of growing heifers with no apparent adverse effect on either animal health or reproduction. While this work should continue until after calving in early 1997, the results so far indicate the great potential for the tree fodder within the production system in the East African highlands.

Introduction

At the start of the animal nutrition project in 1994, it had already been shown that *Calliandra calothyrsus* was well adapted to the Embu region. It was highly productive, except during the coldest months of June and July, and it appeared to be resistant to most of the common pests and diseases found in the area (eg. O'Neill, 1994). Little was known about its animal production potential however, and fears had been expressed at the start-up workshop about the possible adverse effects of feeding it over extended periods of time, because of possible anti-nutritive effects brought on by the known high content of condensed tannins (Palmer and Schlink, 1992; Kaitho *et al.*, 1993). One of the highest priorities of the project was to study these aspects of the tree that had shown its agronomic potential and which was becoming extremely popular with the local dairy farmers.

At Maseno in Western Kenya, amounts of 8 - 10 kg/day of fresh calliandra had been fed to dairy cattle over relatively short duration experiments (van der Veen and Swinkels, 1993). This was shown to be a highly economic practice, especially where the tree fodder was used to replace expensive concentrates. Very few farmers in the Embu region had enough calliandra to feed at these high levels. It was necessary to study the effects on milk production of feeding lower, more practical quantities of the tree fodder. This was done by working with a group of extremely cooperative farmers and extension officers in the Manyatta and Runyenjes Divisions.

Materials and Methods

Experiment 1: During the dry season in August to October 1994, an experiment was conducted on 12 farms (15 cows total) to measure the effect on milk production from grade Ayrshire and Friesian cows. The farms were uniformly small, in the region of about 2 ha, with one or two cows per farm, all kept within a zero-grazed system. The basal diet consisted of Napier grass, together with an assortment of other feeds, including maize stover, banana stems and leaves, sweet potato vines, weed grasses, etc. The cows were milked twice per day, to produce an average of about 10 kg/day.

The farms were selected in conjunction with the divisional extension staff because of the presence of relatively large amounts of calliandra and the presence of at least one cow which had calved 3-4 months prior to the start of the experiment. Milk yield of a cow at this stage of its lactation will respond rapidly to changes in the nutritional value of the diet. Collaborating farmers and extension officers were invited to an initial meeting to discuss the proposed work and to agree on a standard feeding regime that would be used by all participants as the control treatment and the basal ration to which additional components would be added to form the other treatments.

Three treatments were used on all cows in a cross-over design. Each feeding period was of three weeks duration, with one week for adaptation and two weeks for measurements.

1. Control; the farmers own feeding regime, including both 1.25 kg of fresh calliandra and 2 kg of commercial dairy meal (16% CP)
2. Dairy Meal; the calliandra from treatment 1 was replaced by 0.6 kg of additional concentrate
3. Calliandra; a total of 2.5 kg of fresh tree fodder (as for treatment 1, but with an additional 1.25 kg/day of the tree foliage).

The first two treatments were designed to provide the same amount of digestible protein while the third treatment supplied more of this component and therefore would be expected to give the highest milk yields. On a daily basis, feed offered was weighed and milk yields were recorded. At weekly intervals, milk samples were taken for measurement of butterfat content. Although the farms had been selected on the basis of assumed sufficiency of calliandra, some ran short of the tree fodder and had to repeat the control treatment instead of using the extra calliandra treatment. This resulted in an imbalance of the experimental design which necessitated appropriate statistical adjustments.

Experiment 2: In an on-station follow-up to this work, four mature Ayrshire cows at pasture and in their fifth, or sixth month of lactation were fed a daily supplement of 2 kg of commercial dairy meal, fed in the milking bale and split equally between the two milkings, for a period of four weeks, during which the daily milk yield was recorded. Following this, the concentrate was completely replaced for a further four weeks with a daily ration of 6 kg of fresh calliandra leaves, fed as before at the time of milking. Milk yields were recorded daily.

Experiment 3: A second on-farm, cross-over experiment was carried out on 12 farms in the 1995 dry season to look at the additive effects of dairy meal and calliandra on milk production. As before, a meeting of farmers and extensionists decided on the control treatment and the management regime. Four of the farmers who participated in the first experiment also took part in the second one, but the others could not be included because they did not have a cow in the right stage of lactation at the time. In view of the results of the first experiment, it was considered appropriate to reduce the feeding period for each treatment to two weeks, with four days of adaptation followed by 10 days of measurements. The farmers recorded feed offered and milk yields obtained, while again weekly milk samples were collected for butterfat assessment. The treatments were as follows:

1. Control; farmers own feeding regime including 2 - 4 kg of concentrate but with no calliandra
2. Calliandra; as for 1, together with 3 kg of fresh tree fodder
3. Dairy Meal; as for 1, together with an additional 1 kg of concentrate
4. Dairy Meal and Calliandra; as for 1, together with both calliandra and additional concentrate.

Again, even with more stringent selection of farms, two ran short of calliandra and therefore had to reverse the order of treatments. The results were statistically adjusted to take account of this lack of complete balance in the design.

Experiment 4: In a second on-station trial, five grade Ayrshire heifers which had previously been exposed to a range of tree fodders, including calliandra, were selected. At the inception of the work in July 1995 they were about 13 months old, with an average weight of about 212 kg. They were kept at pasture with the dairy herd, under normal farm management including routine, periodic control of ticks and internal parasites. Each afternoon, they were confined in individual pens for about an hour, during which they were offered freshly cut calliandra stems from which they could select the edible portion. No other supplement was fed at any time. The amount of calliandra offered was periodically adjusted for each heifer in accordance with her liveweight averaged over the weekly weighings made in the previous month, such that at an assumed DM content of 30%, the calliandra made up 25% of the estimated daily DM requirement (2.5% of body weight). The amount of calliandra offered and refused was recorded daily and weekly samples of about 0.25 kg of each fraction were taken for oven-drying to constant weight at 60°C for estimation of the DM content of the fodder.

The animals were weighed at the same time (08:00 hours) on the same day each week. They were observed daily at the time of feeding of the tree fodder and any health problems were recorded. They were served by artificial insemination from December 1995 when they were about 19 months of age. Semen from the same, pure-bred Ayrshire bull was used for all heifers to minimize any possible sire effect on the calves.

Results

Experiment 1: The results of the first on-farm trial suggested that the same increase in milk production would result from feeding either 1 kg of concentrate or 3 kg of fresh calliandra. The butterfat content of the milk was increased from 4.0 to 4.5% by the additional calliandra. The data, corrected for the lack of complete balance, are summarized in Table 1.

Experiment 2: During the month of feeding of dairy meal, the average daily yield over all cows was 6.0 kg/day, while in the following month when calliandra was fed, the average yield was 5.8 kg/day. This small reduction in yield was consistent with cows moving into the third trimester of their lactation curves. Considering the results individually, one cow showed a slight reduction in milk yield, probably because she was reluctant to eat all of the calliandra on offer. Two other cows produced almost constant milk yields, while the last one showed a modest increase in the second period. The results are shown in Table 2. This observational trial supported the calculated replacement value of calliandra from the first on-farm experiment.

Experiment 3: Either 1 kg of additional dairy meal or 3 kg of fresh calliandra fodder had the same effect of increasing milk yield by an average 0.4 kg, while feeding both together gave 0.9 kg more than the control. These increases are small, but while the animals are genetically capable of producing higher yields, it may be that they were yielding at close to the maximum possible within the constraints imposed by the existing management system. The differences between treatments were statistically significant ($p = 0.013$) but there was no interaction, indicating that the effects of calliandra and additional dairy meal were totally additive. The main effects of the results are summarized in Table 3.

Calliandra again resulted in higher butterfat content of the milk (Table 3.). The averages over all cows in all of the periods when calliandra was fed was 4.0% and this was statistically superior to the average of 3.7% from the treatments without the tree fodder ($p = 0.018$).

Experiment 4: Previous work had evaluated the plant parts of fresh calliandra which were readily consumed by the same heifers. Detailed measurements showed that the bulk of green material from lateral branches was taken up to a diameter of 0.4 cm, while the terminal shoots were eaten to a diameter of 0.5 cm. When the material was very lush during the wet season, however, young shoots were taken up to a diameter of 1.1 cm (R L Roothaert, unpublished).

The consumption of fresh calliandra varied between individual animals. Although there was a general trend for consumption to increase over time as the animals grew and their total feed intake increased, this was greatly influenced by the quality and quantity of pasture on offer. The average calliandra intake over the five animals for the ten months of the trial to date was 2.90 kg/day of fresh fodder. This would provide about 1.0 kg/day of DM, equivalent to some 13% of the daily requirement of a heifer of 300 kg liveweight. This level of voluntary intake is low in comparison with lactating cows in the same herd which readily took up to 6 kg/day of fresh calliandra (about 2 kg/day DM) when at pasture (Experiment 2).

All of the animals gained weight steadily throughout the period of the trial. While the regular feeding of calliandra started in July 1995, problems developed with the scales about a month later. For this reason, the weights recorded for the month of August 1995 are not presented. The group mean monthly weights are shown in Figure 1. While the growth rates have varied slightly during the period according to the quality and quantity of the basal diet that has been offered, the average daily gain over the 39 weeks from mid July 1995 to mid April 1996 was 0.55 kg/day, with individual animal gains ranging from 0.52 to 0.59 kg/day. These are excellent growth rates from dairy heifers kept on a basal diet of tropical pastures without any commercial concentrates. The monthly mean liveweight for April 1996 was 362.7 kg (range 340 to 379 kg).

Discussion and Conclusions

Although the differences between treatments in the first three experiments were small and in some cases failed to reach statistical significance, taken together the trends in milk production were consistent and clear. Calliandra increased milk yields and also improved the butterfat content of the milk. Further, these observations were supported by the growthrates of the heifers in the long-term feeding experiment, since the performance of the animals was obviously enhanced by the feeding of calliandra. It therefore seems obvious that the tree fodder can make a useful supplement for use with dairy cows.

Under the management system employed in the Embu area and at the observed levels of milk production which commonly peak at some 15 kg/day and then decline to about 10 kg/day in the third or fourth month of lactation, the conclusions from the work so far conducted can be summarized as follows:

- during the August-September period when quality feed is scarce, 3 kg of fresh calliandra fodder has the same positive effect on milk production as 1 kg of additional commercial dairy meal with 16% crude protein. The response in both cases appears to average about 0.5 kg of milk.
- calliandra can be used at this replacement level to substitute for dairy meal, without decreasing milk yields. Alternatively, it can be fed in addition to the concentrate with a consequent increase in yields.
- the yield effects of calliandra and dairy meal are totally additive, with no discernible interaction.
- calliandra has consistently increased the butterfat content of the milk. Although there is no premium paid for milk quality in the Embu region at this time, it seems that recently, consumers of milk from small, private dairies in Nairobi are being offered three contrasting grades of milk with prices set according to the fat content. If this becomes a national trend, it may not be long before a similar situation occurs in Embu. In the meantime, the additional butterfat is already appreciated by farmers, many of whom have noted either "thicker", or "stronger" milk, with a deeper colour as a result of feeding of calliandra.

With regard to the long-term supplementation of animals with calliandra, the work is still in the preliminary stages as it is planned to continue feeding the tree fodder on a daily basis until at least two months after the animals calve down in late 1996 or early 1997. They have so far been eating a daily ration of the tree fodder for over ten months however, and the observations to date have been extremely positive.

As implied from the high growth rates, no major health problems were noted in any of the animals. They started to come on heat from July 1995 at about 230 kg liveweight. They displayed normal heat periods from the time of its inception, although service was delayed until a liveweight of about 280 kg was achieved from December 1995. Two of the heifers were confirmed pregnant after the first service, one after the second and one after the third insemination. The last animal showed what appeared to be a false heat two weeks after being inseminated for the first time. She has been served again, but at the time of writing, pregnancy is not yet confirmed. While these results give no reason for complacency, neither do they indicate a serious problem of infertility. There is no reason to suppose that prolonged feeding with calliandra has had an adverse effect on either heat or conception.

While the work is as yet incomplete and it will be necessary to establish the normality of the calves before making claims regarding the appropriateness of calliandra for long-term feeding of heifers and breeding cows, the results obtained so far are most encouraging and give no cause for concern.

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Table 1. Adjusted daily milk yields (kg) and average butterfat contents (%), Manyatta and Runyenjes, August to October 1994

Feed	Milk Yield (kg)	Butterfat Content (%)
1. Normal	10.1	4.0
2. Dairy Meal	10.3	4.3
3. Calliandra	10.5	4.5
sed	0.25	0.12

sed standard error of difference

Table 2. Average weekly milk yields (kg) of cows fed either 2 kg commercial dairy meal or 6 kg of fresh Calliandra, KARI RRC, Embu, March to May, 1995

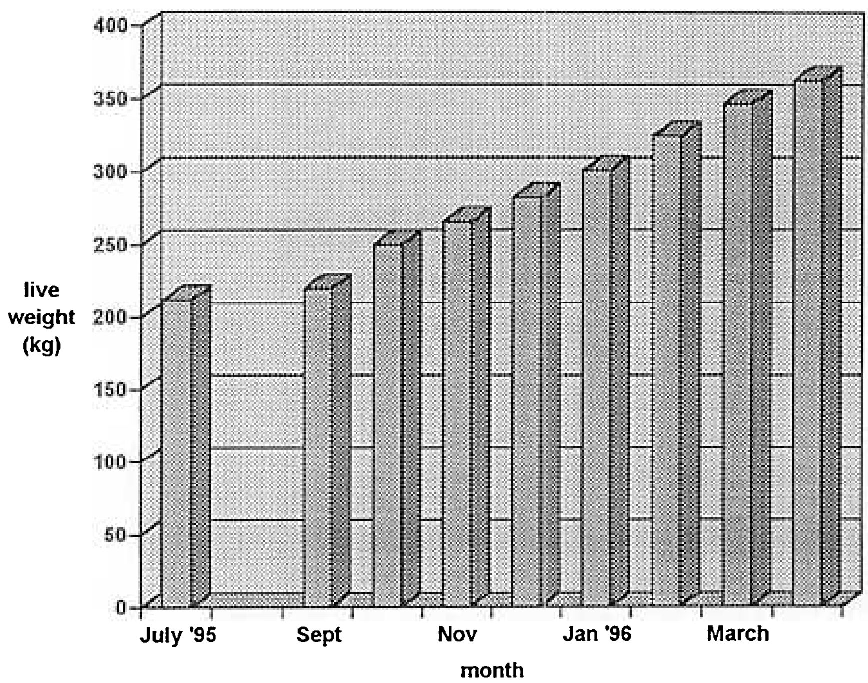
Week	cow 87	cow 76	cow 99	cow 111	Mean
Dairy Meal					
1	7.2	7.3	4.3	4.4	5.8
2	8.4	7.3	4.5	4.6	6.2
3	9.1	6.9	4.3	4.3	6.2
4	9.3	6.2	3.5	4.3	5.8
Mean	8.5	6.9	4.2	4.4	6.0
Calliandra					
5	8.3	6.6	4.2	4.6	5.9
6	8.4	6.3	5.5	4.8	6.3
7	7.9	4.6	5.3	4.3	5.5
8	8.1	4.2	5.2	4.3	5.5
Mean	8.2	5.4	5.1	4.5	5.8

Table 3. Main effects of feeding Calliandra and additional dairy meal on milk yield (kg) and butterfat (%), Manyatta and Runyenjes, August to September 1995

	Milk yield (kg)	Butterfat content (%)
Dairy meal		
no extra	10.72	3.9
1 kg extra	11.15	3.9
Calliandra		
none	10.70	3.7
3 kg	11.17	4.0
sed	0.22	0.11
cv	7.1	10.0

sed standard error of difference
cv coefficient of variation

Figure 1 Group mean monthly weights of five heifers fed a daily supplement of *Calliandra calothyrsus*



Note: weights for August 1995 are not presented because of problems with the cattle scale.

Discussions on Paper 9 (Kariuki)

Q. What kind of statistical design was used in the on-farm trials and if a latin square design was used, then there should be no interaction effects.

A. The design used was a Latin square. The data were later subjected to factorial type analysis (milk production from treatments with and without calliandra) and hence the interaction effects. (**Editors Note:** *This answer is incorrect, since it refers to the on-station trial reported in Paper 6, pages 33 to 38 above, rather than to the on-farm trials. In both of the on-farm milk production experiments, a cross-over design was used, where all animals were subjected to all treatments and all treatments were represented in all periods. This provides a ready estimate of interaction.*)

Q. What would be the spacing of calliandra if planted in blocks?

A. The normal practice is to plant calliandra in hedges at intra-row spacing of 30-50 cm. The yield figures presented for block planting are from extrapolation of the hedgerow yields.

Q. The fourth treatment in the on-farm trial (control + 1 kg dairy meal + 3 kg fresh calliandra) gave 0.9 kg of milk more compared to the control. Is it worthwhile to give these extra feeds?

A. The economic benefits from feeding calliandra amount to KShs. 5,500.00 per cow per year. There is sustainable dairy supplementation with calliandra as opposed to dairy meal whose availability may be erratic depending on the farmer's financial status.

Paper 10.

Calliandra and Mulberry (*Morus alba*) in poultry rations

R. T. Paterson, R. L. Roothaert and I.W. Kariuki

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Abstract

In a small-scale commercial battery operation, the effects of inclusion levels of 0, 5, 7.5 and 10% dried leaf meal of either *Calliandra calothyrsus* or *Morus alba* were studied on the production and efficiency of young, laying hens. The highest level of either leaf meal reduced egg production and feed efficiency (eggs/unit of feed), this being accompanied by a reduction in feed intake with the mulberry. Calliandra resulted in small weight losses of the birds, most of which was recovered during the subsequent mulberry period. There were no significant treatment differences in terms of egg weights, although there was a suggestion of an increase in egg size which largely offset the reduction in egg numbers in the high mulberry treatment. Calliandra was a much more efficient source of yolk pigmentation than mulberry, Roche colour fan ratings being increased by about 4 and 2 units respectively at 5% inclusion of the two species. It was concluded that neither tree species showed much potential for inclusion in diets based on commercial meals, possibly due to the presence of anti-nutritive factors in the foliage.

Introduction

Producers of eggs and poultry meat in Kenya are faced with a situation where, in recent years, animal feed prices have increased faster than the purchasing power of the local population. Profit margins have been reduced so much that some small-scale producers have been forced out of business. It was reasoned that if commercial rations could be extended by the incorporation of high quality, locally produced tree fodders, this should reduce feeding costs, increase profit margins for the producers and possibly bring purchased poultry products back into the shopping basket of poorer consumers.

In previous work in with laying hens, it was shown that the inclusion of a range of tree fodders in the diets at inclusion levels of up to 20% resulted in reduced feed intake and efficiency of feed utilization. It was suggested that this effect was related to the high fibre content of the tree leaf meal (D'Mello, 1995). In Kenya, with birds in the latter stages of their egg production cycle, the addition of dried leaf meal of *Calliandra calothyrsus* (callianda) to commercial layers meal at inclusion levels of up to 10% (as fed basis) had a strong, positive effect on yolk coloration but a small negative effect on numbers of eggs produced per unit of feed consumed (Paterson *et al.*, 1996). The present work was undertaken to confirm these observations with younger birds and to compare the effects of calliandra with those of the common mulberry (*Morus alba*). This is a tree which has traditionally been used to feed silkworms and is showing considerable promise in the Kenyan highlands as a source of fodder for ruminants (R. L. Roothaert, unpublished). Little is known, however, about its potential for feeding to poultry.

Materials and Methods

The work was conducted in a small-scale commercial battery operation located in a closed room. Artificial lighting was provided at night by a single bulb at ceiling height. The unit had a capacity of 160 birds, kept two to a cage in banks of 5 cages (10 birds) feeding from a communal feed trough. The birds were routinely fed on a commercial layers meal with a nominal analysis of 12% moisture (maximum); 15% crude protein (min.); 6% crude fibre (max.); 2-6% crude fat; and 4% acid-insoluble ash (max.). The statutory level of calcium was in the range of 2.8-3.7%, with minimum levels of phosphorus, copper, manganese and zinc of 0.4%, 5, 50 and 50 ppm respectively. All birds had permanent access to fresh water. All 16 banks (160 birds) were used for the experiment and contemporary birds were held in reserve in an adjoining enclosure in case of losses. The birds were Rhode Island Red hybrids, hatched on 18 June 1995. They started laying in December 1995 and were seven months old at the start of the experimental work in January 1996.

A single lot of the commercial layers meal was used for the whole of the experiment. The bags were emptied and the feed was thoroughly mixed to ensure uniformity of the basal ration. It was divided into equal halves for the two parts of the work, one with calliandra and the other with mulberry.

Foliage of calliandra and mulberry was harvested as regrowth of 2-3 months from intensively managed, mature trees maintained for fodder production, as pure-stand blocks on the KARI Regional Research Centre, Embu. Calliandra leaf meal grown under these conditions routinely has a crude protein (CP) content in excess of 25% (dry matter basis), while mulberry leaves have been shown to contain about 19% CP (Thijssen *et al.*, 1993). The site characteristics (O'Neill, 1995) were as follows: altitude 1480 m; average annual rainfall, 1230 mm in two wet seasons; soils humic Nitisols with moderate to high fertility.

Sufficient foliage of each tree species was harvested for the whole trial. It was air dried in the shade to a moisture content of about 12% when the leaflets of calliandra readily fell from the petioles and the leaves of the mulberry separated easily from the stems. The leaf material was passed through a laboratory mill to form ground leaf meals. The species were kept totally separate and the meal from each was thoroughly mixed. Separate sets of rations of calliandra and mulberry were then prepared on an "as fed" basis, using the air dry materials as follows:

1. control: 100% commercial layers meal
2. 5% leaf meal (calliandra or mulberry) and 95% commercial layers meal
3. 7.5% leaf meal (calliandra or mulberry) and 92.5% commercial layers meal
4. 10% leaf meal (calliandra or mulberry) and 90% commercial layers meal

After careful mixing of the constituents, the feed of each ration was weighed into separate bags of 1.00 kg each for ease of handling and to prevent any possible separation of the components.

No adaptation period was thought to be necessary, as the basal ration was the same commercial meal that the birds were used to consuming. The banks fell naturally into blocks of four which shared a common position and aspect within the poultry house. These were taken as replicates and the four treatments were assigned at random in a randomized block design. The calliandra-based diets were fed for the first five weeks of the experiment and at the conclusion of this period, all birds returned to their normal diet (excluding tree fodder) for a further three weeks. Subsequently, the mulberry-based rations were fed for another five weeks. For the whole of the 13 weeks of the work, feed offered and refused was measured at the same time every morning and the number of eggs produced by each bank (10 birds) was counted every evening. Once per week, the birds were weighed in pairs (liveweight from each individual cage) and the weight of eggs produced from each bank of 10 birds was recorded. One egg was then taken at random from each bank for assessment of yolk colour by use of a Roche yolk colour fan.

Results

No losses were recorded during the experiment and so all birds remained in their cages for the whole 13 week period. Acceptance of the calliandra diets was immediate, with no evidence of reluctance on the part of individual birds. At the higher levels of mulberry inclusion, intake was reduced during the first few days, but rapidly reached normal levels (Figure 1). No adaptation period was therefore thought necessary and the results presented in Tables 1 and 2 are averaged over the whole of each feeding period.

Calliandra period: Overall, the average weekly feed intake increased from 1.41 up to 1.61 kg/day/bank of 10 birds over the first three weeks of the period, before settling back to a level of about 1.47 kg/day/bank for the last two weeks of feeding (Figure 1). These changes were due to unidentified, non-treatment effects, as the treatments were statistically similar (Table 1). Similarly, the birds lost weight at an average of 4.2 g/day over the whole period (Table 1), but this appeared to be related to position within the poultry house, rather than treatment. Overall egg production over this period fell from 7.3/bank in the first week to about 6.9/bank for the rest of the period (Figure 2). Both egg production (Table 2) and feed efficiency (Figure 3, Table 1) showed statistically significant differences ($p=0.025$ and 0.046 respectively). In both cases, the 10% calliandra was noticeably poorer than the other treatments (Table 1).

Egg size, measured as average weight, varied from week to week, possibly due to sampling error, but showed no treatment differences (Table 2). Yolk colour, however, was greatly affected by treatment ($p<0.001$), with Roche yolk colour fan average scores increasing from 7 (an acceptable, yellow-orange) in the control, up to 11 (a bright orange) at the high level of calliandra (Table 2).

Uniformity period: During the three weeks between feeding of the tree fodders, feed intake fell below the levels noted during the calliandra period (Figure 1) and this was accompanied by an increase in both egg production (Figure 2) and consequently, feed efficiency (Figure 3). The birds continued to lose weight, although at a reduced rate of about 1.1 g/day. Egg weight fell to below the levels of the previous period, while yolk colour became a rather pale and unattractive yellow (Tables 1 and 2).

Mulberry period: Feed consumption showed a continual increase over the whole of the feeding period, ending at the same level as the peak of the calliandra phase, which had occurred in week three (Figure 1). The differences were statistically significant (p=0.002), with the highest consumption occurring in the 5% mulberry treatment and the lowest in the 10% tree fodder (Table 1). These differences were reflected in egg production (p=0.053), with the result that feed efficiency was similar between all treatments (Tables 1 and 2, Figure 3)). All birds gained weight during this period at an average of 2.5 g/day. The treatment differences were statistically significant (p=0.028). In general, increasing levels of mulberry inclusion gave lower weight gains, although the lowest weight gains of all were from the 5% mulberry treatment which also gave the highest egg production.

Overall, egg weights (Table 2) showed a significance level of p=0.076. Although this is below conventional levels of statistical acceptance, there was a consistent trend across replications for the heaviest eggs to come from the high mulberry treatment which had given fewest eggs. There appeared to be a trade-off between egg numbers and egg size. Yolk colour was intensified (p<0.001) by the inclusion of mulberry in the ration, although the increase in Roche colour fan rating was only about half of that produced by the calliandra (Table 2).

Discussion

Production levels shown in Figure 2 and Table 2 were higher than in previous work conducted in this series of experiments, but this is to be expected. In the present work, the birds were young, in the early stages of their production cycle, while in the earlier experiment, they were approaching the end of their productive life. Further, the weather during this period was warmer than in the previous work, without being excessively hot. Such conditions, with ambient temperatures of below 32°C, favour optimum levels of egg production (Smith, 1990).

The results obtained with calliandra in the present work, in terms of egg production, feed efficiency, egg weight (size) and yolk colour were almost totally consistent with previous experiments conducted in Kenya and elsewhere (D'Mello, 1995; Paterson *et al.*, 1996). Bird weight changes and feed consumption showed similar, but less well defined, generally negative trends. It would therefore appear that the stage of lay of the hens is almost irrelevant in the effects of including calliandra leaf meal in diets based on commercial layers meal. In such rations, calliandra shows little potential as a diet extender, as efficiency of production decreases with increased inclusion levels. It does, however, show potential for inclusion as a source of pigmentation for egg yolks, either at low levels (perhaps 2-5%) on a daily basis, or alternatively at higher levels (about 10%) every few days (Susana *et al.*, 1992; Tangendjaja *et al.*, 1992; Paterson *et al.*, 1996). This conclusion does not reflect on the possible usefulness of calliandra as a source of protein in rations based on locally available energy sources, even though the known high tannin content of this tree species (eg Palmer and Schlink, 1992) could potentially result in reduced digestibility of both the organic matter and the protein fraction of the whole ration. This aspect requires further research to fully define the role of calliandra in the feeding of poultry.

During the uniformity period between feeding of calliandra- and mulberry-based diets, all treatments were fed on the same diet without tree fodder. Feed intake fell, egg production increased and there was a consequent increase in feed efficiency to levels above the control group in either leaf meal period (Figures 1, 2 and 3). The feed used in the experimental rations was of the same type and from the same manufacturer as that fed during the uniformity period. It was, however, from a different batch and thus the quality may have varied. Conversely, there may have been unidentified ambient factors that increased production during this period.

With regard to feeding of mulberry to laying hens, there is little information in the literature. The present experiment showed that inclusion levels of 10% led to reduced feed intake, egg production and feed efficiency, although this was accompanied by an increase in the weight of individual eggs that tended to offset the reduction in egg numbers. At the lowest inclusion level employed (5%), feed consumption and egg production both increased, but there was a non-significant decrease in feed efficiency.

All levels of mulberry feeding led to an increase in the Roche colour rating of about 2 units, but there was no clear colour response to levels above 5%. It would therefore appear that there may be a case for utilization of mulberry at levels of about 5% in diets based on commercial layers meal, but increasing inclusion levels above this level could result in reduced productivity. Mulberry is clearly a much poorer source of pigmentation than calliandra and if this is a major consideration, the latter species would be chosen over the former.

In general terms, mulberry showed no greater potential for inclusion in diets based on commercial meal than either calliandra, or other dried leguminous tree fodders, including *Leucaena leucocephala, Gliricidia sepium* and *Cajanus cajan*, which combine high levels of both crude protein and crude fibre. It is known that many tree fodders contain anti-nutritive factors which can affect the utilization of the diet. Both condensed tannins and saponins are universally distributed in leguminous species, while some species also contain other chemicals such as non-protein amino acids (eg. *L. leucocephala*), alkaloids (eg. *G. sepium*), etc. (D'Mello, 1995). Little is known about the presence of anti-nutritive factors in mulberry foliage, but since it has a high crude protein content and is reportedly very well digested, at least in ruminants, it is possible that unidentified factors reduced its effectiveness in the present work.

Acknowledgments

As with the previous work in this series, it would not have been possible without the full and active collaboration of the farm manager and staff at Don Bosco Technical Secondary School (Boys), Embu, Kenya, the technical assistance of the KARI technician, Mr N. Murithi and the support of the Director, KARI Regional Research Centre, Embu.

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Table 1. Daily feed intake (kg), feed efficiency (eggs/kg of feed) and average bird weight changes per period (g). Means over 4 banks of 10 chickens fed varying levels of dried meal of *Calliandra calothyrsus* and *Morus alba*.

Treatment	Feed Consumed kg/10 birds/day	Feed Efficiency eggs/kg of feed	Weight Changes g/period
Calliandra Period			
control	1.45	4.98	-125
5% leaf meal	1.53	4.73	-123
7.5% leaf meal	1.46	4.82	-90
10% leaf meal	1.46	4.42	-128
sed	0.033	0.168	28.5
cv (%)	3.1	5.0	*
p	0.143	0.050	0.542
Adjustment Period			
control	1.25	7.57	-52
5%	1.35	7.85	-10
7.5%	1.31	7.50	-12
10%	1.30	7.35	-12
sed	0.025	0.21	18.6
cv (%)	2.7	1.7	*
p	0.018	0.165	0.133
Mulberry Period			
control	1.45	4.62	+125
5% leaf meal	1.56	4.36	+58
7.5% leaf meal	1.47	4.28	+100
10% leaf meal	1.39	4.19	+60
sed	0.056	0.32	20.9
cv (%)	3.2	6.1	*
p	0.009	0.441	0.028

* Coefficient of variation (cv) not valid where changes can be either positive or negative

Table 2. Egg production (No.), average egg weight (g) and yolk colour. Means over 4 banks of 10 chickens fed varying levels of dried meal of *Calliandra calothyrsus* and *Morus alba*.

Treatment	Eggs Produced Total/day, 10 birds	Average Egg Weight (g)	Yolk Colour Roche score
Calliandra Period			
control	7.2	72	7.1
5% leaf meal	7.2	70	10.5
7.5% leaf meal	7.0	70	10.8
10% leaf meal	6.4	69	11.1
sed	0.23	2.1	0.43
cv (%)	4.6	4.1	6.1
p	0.026	0.640	<0.001
Adjustment Period			
control	7.6	62	4.8
5%	7.9	61	5.0
7.5%	7.5	61	4.8
10%	7.4	62	4.8
sed	0.26	1.5	0.34
cv (%)	4.9	3.4	9.9
p	0.307	0.940	0.844
Mulberry Period			
control	6.9	61	5.1
5% leaf meal	6.8	60	7.2
7.5% leaf meal	6.3	61	7.5
10% leaf meal	5.8	64	7.5
sed	0.32	1.5	0.30
cv (%)	6.7	3.3	6.2
p	0.109	0.139	<0.001

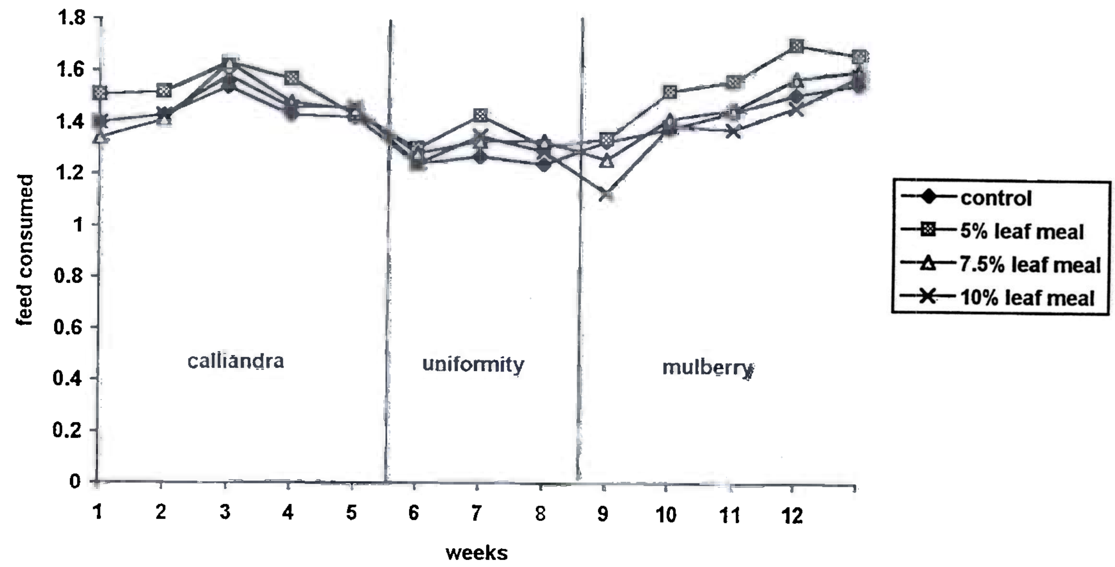

Figure 1. Daily feed consumption (kg) per bank of 10 birds (averages over one week)

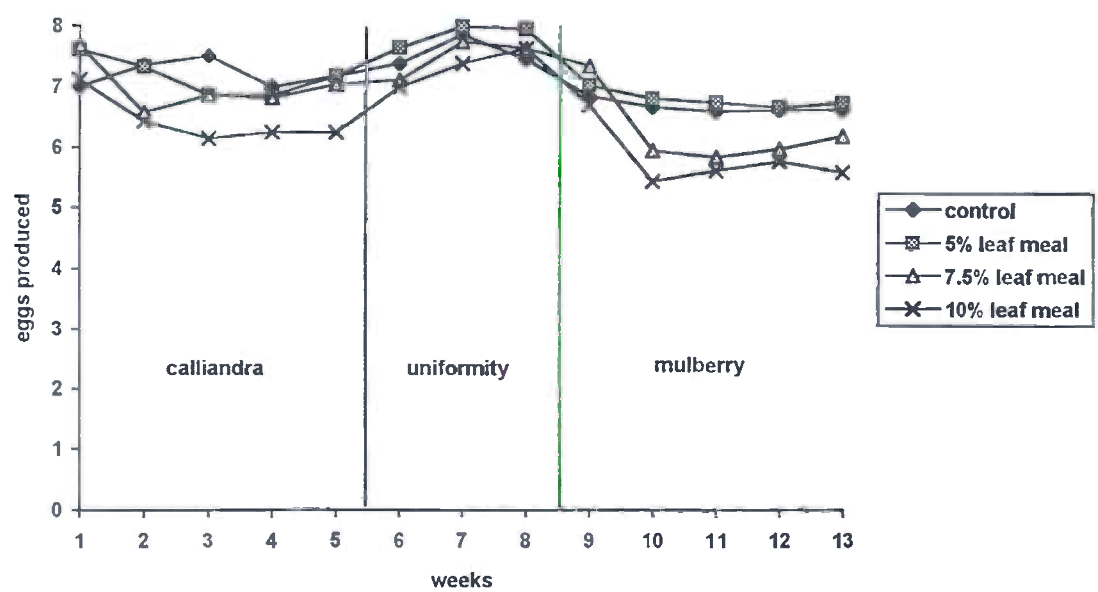

Figure 2. Daily egg yields per bank of 10 birds (averages over one week)

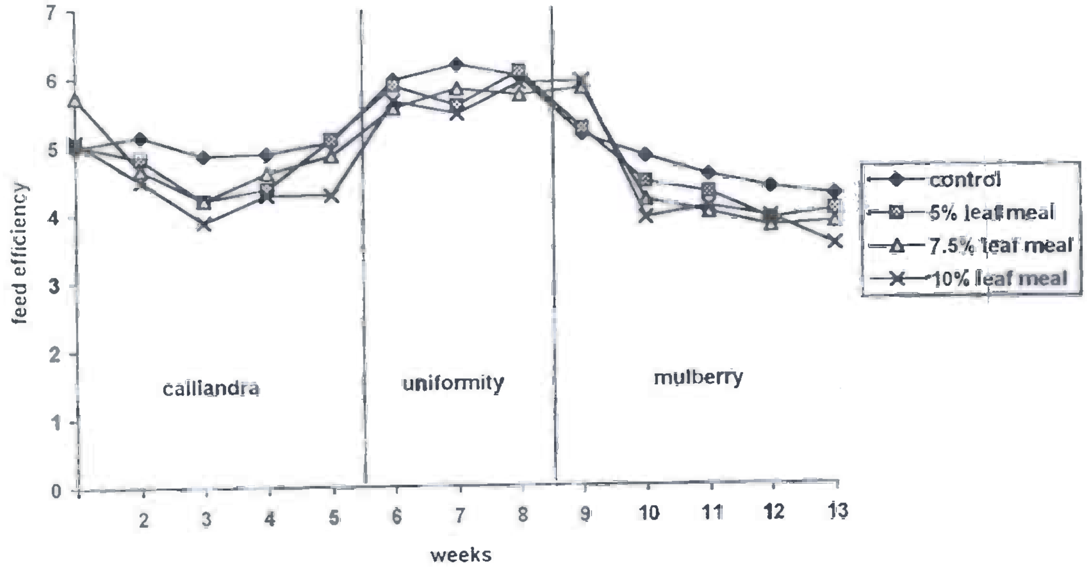

Figure 3. Weekly feed efficiency (eggs produced per kg of feed consumed)

Discussions on Paper 10 (Kariuki)

Q. How was calliandra dried before being ground.

A. It was air-dried in the shade after cutting every 2-3 months. The leaflets separated from the stalks and were ground using a mill.

Part III

Plenary Discussions

Discussions on the workshop, the completed project, dissemination of results, and the need for a second phase

Chairman: Dr. J.G. Mureithi, Assistant Director, RRCs
Rapporteurs: I.W. Kariuki and E.M. Kiruiro (RRC-Embu)

1. General comments on individual presentations

The comments have been exhausted in the previous sessions.

2. Outputs from project activities versus initial objectives

Generally, the project activities have been in line with the initial objectives.

3. Impact of project activities taking into account extension/farmer perspectives

It was noted that although there is a wealth of knowledge on fodder trees generated by various organizations (e.g. NDDP), not much information has yet been passed on to extension staff.

It was felt that most of the activities presented in this workshop are still on-going and there is little ready for dissemination. For example, the goat work focused only on monitoring, with no research being conducted.

In order to have more impact, there is need:

for more conclusive results on some of the issues. For example, with regard to the economic benefits of feeding calliandra to dairy cattle, it should be clearly indicated the target group being considered.

ii. to present results in a summarized form in Training and Visit workshops in all the mandate districts.

4. Sustainability (Potential adoptability/Extent of adoption)

It was felt that in areas outside of Embu district, calliandra has not been popularized enough. For example, a recent survey on tree nurseries in Murang'a district indicated that calliandra was non-existent.

With regard to multiplication of fodder trees, a proposal was floated to use nurseries within the forestry department. However, it was felt that these nurseries may not be appropriate because of lack of funding. Women's groups could start on-farm tree nurseries.

With regard to unavailability of calliandra seed, it was suggested that the fallow land in Farmer Training Centres (FTCs) could be used for seed production of calliandra.

If individual farmers want to produce calliandra seed, they should have at least 30 trees in a block which are allowed to flower, to ensure genetic diversity. Bats are the pollinators of these trees and it can take some time before they discover the trees.

The focus on Calliandra was questioned, since the foliage is known to contain tannins and condensed tannins can kill some rumen micro-organisms and bind feed proteins in unavailable complexes. Why not work on other fodder/herbaceous legumes? It was noted that most legumes contain anti-nutritive factors of one sort or another. The long term effect of feeding calliandra to heifers at the research station will elucidate the effect of calliandra on long term productivity of dairy cattle.

There is also the need to provide farmers with various fodder species for them to make a choice. For example, *Trema orientalis, Sapium ellipticum, Leucaena diversifolia*, and other varieties of Calliandra, etc.

There is need for creation of model farms in other districts where extension staff can see the benefits of fodder trees in the production systems.

5. Overall Assessment of the workshop

The weak points were covered in the discussions.

6. Phase II

Phase II is clearly warranted. The issues that deserve emphasis are presented below.

Recommendations for Phase II

1 Broaden the base of the various fodder species to work on, to provide farmers with greater choice.

2. Look at ways of preserving tree fodder so as not to be limited by a cut and feed system since, for example, when calliandra is dried or wilted, it becomes indigestible.

3. The need to look at the design of experiments and the number of experimental units.

4. The need to develop local methodologies on livestock experimentation, especially on-farm.

5. Scientists should strive to gather scientific data taking into account farmers needs.

6. Look for ways of making calliandra seeds available to farmers.

7 Popularize calliandra in the farming community outside of the Embu District, through the use of pilot farms and demonstrations.

8. Since most of the activities have not been concluded yet, it is too early to assess impact at farm level.

9. There is need for more focused economic assessment of technologies for specific target groups.

Concluding remarks

At the conclusion of the workshop, Mr S. P. Gachanja, Director of the KARI Regional Research Centre in Embu, thanked the participants for their attendance and contributions to the deliberations. He reiterated the need for dissemination of research findings to the farming community. All channels of dissemination should be exploited; including chiefs, District Officers, tours to the centre/farms by farmer groups, etc.