R6775 - Evaluation and Improvement of Feeding Strategies for Optimising Feed Intake in Crop/livestock Systems.

Volume 1 – Executive Summary

A Final Technical Report on a Research Project Funded by the Department for International Development's Livestock Production Research Programme

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Background

The underlying causes of feed shortages and poor feed quality are complex and interacting. This project attempted to integrate the scientific assessment of these underlying causes with the needs of farmers in its target communities and beyond.

The productivity of many livestock production systems in developing countries is constrained by poor nutrition. This is due to feed shortages and poor quality of those feeds that are available. This is particularly the case where nutritional demands are high, such as with dairy animals. Feed shortages result from limited access to feeds, seasonality of production, inadequate labour available for collection and feeding, and high costs while poor feed quality encompasses low digestibility and nutrient contents, presence of anti-nutritive factors, low palatability and low voluntary feed intake.

All of these diverse factors must be considered by farmers in relation to the strategies that they use for manipulating the feed intakes of their animals. Their task is complicated by the fact that their holdings include a number of different species and classes of livestock, each with multiple and changing production objectives, as well as varying demands for labour and other inputs into any cropping activities. However, farmers employ a wide range of feeding practices that are aimed at manipulating and optimising feed intake. These include the manipulation of the daily order, frequency and timing of feeding or grazing, night feeding, offering feeds in excess of requirements to allow selection, and various supplementation practices with a variety of feeds.

To date, researchers have displayed a poor understanding of this complex task facing the farmer who is deciding on optimum feeding strategies. There have also been only limited investigations of farmers' current practices for optimising intake, the reasons for their adoption and the mechanisms by which they achieve their objectives. This has led to a lack of integration between innovative and existing practises which may go some way towards explaining the relatively poor uptake of technologies developed for improving nutritional status by promoting feed intake. In general, methodologies for farmer-participatory research in livestock production have been considerably less developed than in the fields of crop production and crop protection.

Dairy systems were targeted by the project due to the established importance of dairying as means of enhancing farm livelihoods. Furthermore, it was considered dairy farmers, who often already invest significant inputs, in terms of provision of labour, supplements etc, were likely to represent a target group that would be repsonsive to new feed management technologies.

Identification of Demand

The project responded to a broad-based demand within the NARS that identified nutrition as a key constraint on the positive contributions of livestock

In 1991 The Kenya Agricultural Research Institute (KARI) cited dairy production as one of the highest priorities under their 'Research Priorities to the Year 2000'. Nutrition was identified as an area requiring support under the DfID-funded NARP II (National Agricultural Research Project) following assessment of problem identification exercises in the field.

The primary target institution of the current project was therefore KARI, which also collaborated directly in the project's activities. Since a key aim was to develop improved strategies that could be used by farmers, the Kenya Ministry of Agriculture, Livestock Development and Marketing (MoALDM) was also targeted. The integration of these stakeholder institutions was greatly facilitated through the KARI / MoALDM / ILRI programme of research and development activities supporting the smallholder dairy systems that supply the Nairobi milk market. These activities were funded under ILRI's core budget and substantially by further, bi-lateral allocations made by DfID. One of the key aims of this programme has been to strengthen research-extension 'cluster' groups

established at each KARI centre to link farmers, extension workers and research scientists. Close linkages were also maintained with KARI staff working on the Livestock Feeds Component of NARP II focusing on the nutrition of the lactating dairy cow.

Researchable Constraints

The present project sought to identify how farmers manipulate intake, the control mechanisms operating and whether the observed systems can be improved by incorporating proven technologies or improving the farmers own methods of manipulation.

As described above, the project was linked to the KARI / MoALDM / ILRI project '*Research and Development to Support Smallholder Dairy Systems to Supply the Nairobi Milk Market*'. This is turn has been involved in an adoption study funded by the LP Programme (R6153) focusing on the introduction of planted forages and which is to study the introduction of shrub legumes into dairy farming systems. In LPP project, R5732 '*Development and On-farm Evaluation of Agroforestry Livestock Feeding Systems*', carried out at the KARI Regional Research Centre in Embu, the use of Calliandra as a supplement was studied. Furthermore, the Livestock Feeds Component of the NARP II project has examined the efficacy of a number of ways of improving utilisation of available feed resources. The current project attempted to integrate much of the information arising from these sources into feeding and management strategies for alleviating the widespread constraint of inadequate dairy cow nutrition.

Review of Literature

This section presents an overview of the relevant literature. More detailed literature reviews are included in the appendices.

In the past, scientists have developed many technologies for manipulating feed intake based on a knowledge of controlling mechanisms. One of the primary factors affecting intake of low quality fibrous forages common in the tropics is physical fill (Forbes 1995) which is, in turn, dependant on rates of passage and digestion (Ulyatt *et al*. 1986). A number of strategies, including alteration of physical structure by, for example, chopping (Osafo *et al*. 1993), increased selection (Owen and Aboud, 1988), chemical treatment (Schiere and Ibrahim 1989, Schiere and Nell, 1993) and supplementation with a protein source (Smith et al., 1990; Premaratne, 1991; Khalili *et al*., 1994) have been developed with a view to altering these parameters, thereby increasing intake.

Although significant production responses have been observed using these technologies, adoption rates are often low. The exact reasons for this are not always clear but, in many cases, may reflect a lack of consideration of farmers' objectives and other, non-technical constraints. Where "improved" strategies involve significant inputs of cash and labour, there may be a conflict with demand from other activities in the system. Where the main constraint is a lack of feed, farmers seek to manipulate intake of different feeds to make best use of available resources and optimise the efficiency of nutrient utilisation rather than maximise intake.

However, it has been observed that farmers do employ strategies affecting intake. For example, Thorne (1993) noted that farmers in Nepal altered timing of feeds so that less palatable straw was fed before fresh grasses to ensure maximum intake. Tanner *et al*. (1993) found that Indonesian farmers offered large amounts of grass to sheep to allow feed refusals to mix with faeces and urine to produce a good quality compost which was a major output of livestock rearing. Dhaubadel and Tiwari, (1992) noted that, where forages are in short supply farmers may deliberately restrict intake. In Kenya dairy farmers use a variety of novel feeds including cabbage leaves and banana stems to maintain the nutrient intakes of animals fed a limited supply of cultivated Napier grass (Abate *et al*. 1990). In Tanzania farmers deliberately restricted grazing time of goats to avoid behavioural problems (Romney *et al*. in press)

Project Purpose

The project was intended to contribute to output 1.4 of the LPP's high potential production system

Output 1.4 of the LPP High Potential Production System is:

> "*Improved strategies for animal husbandry and nutrition in the intensive livestock production systems and in crop/livestock systems in high potential and peri-urban areas developed and promoted*"

The current project contributed to this output by improving our background knowledge of feeding strategies used by farmers to address their own, broad objectives. The management strategies developed by the project aimed to incorporate these objectives in order to improve adoption rates.

Research Activities

The project activities specified in the original memorandum were:

Activity 1 - *Field studies* to establish the range of feeding strategies found in the target system.

Activities 2 and 3 - A series of *On-station studies* to test three hypotheses:

- That feed intake is responsive to the feeding practices adopted by farmers with the aim of manipulating it.
- That the factors limiting responses, in terms of feed intake, to these farmers' practices may be identified.
- That complementary practices may be identified which will increase flexibility in intake manipulation by farmers.

Activity 4 - *On-farm studies* to evaluate improvements in livestock productivity due to improved feeding strategies as implemented and adapted by farmers in the target systems.

Activity 5 - *Dissemination workshop* to identify approaches that would allow the project's findings to be assimilated by its target institutions (notably the DfID-funded Smallholder Dairy Project (SDP) in Kenya).

Implementing the Project

During the project's implementation, it became apparent that these activities would be too narrow for the proposed research to contribute to the developmental problems identified within the study system.

As a result, the project's activities were re-focussed around four main areas:

- Establishing existing feeding practices (*as per* original activity 1).
- Examining the nutritional implications of short variations in feed intake (original activities 2 and 3 but informed by the initial field and other studies).
- Application of improved management strategies in maize based farming systems (original activity 4 augmented with further on-station work).
- Final dissemination work (as per original activity 5).

Outputs

This section of the report provides a brief overview of the project's outputs.

These are described in more detail in the various project publications that are included in the accompanying appendices.

Feed Resource Utilisation in Kiambu, Kenya

The baseline studies of feed resource utilisation in Kiambu, Central Kenya consisted of an initial PRA with a follow-up longitudinal study over a 15 month period in 1997 – 1998.

A Participatory Rural Appraisal (PRA) was conducted with smallholder dairy farmers in the Central Highlands of Kenya, where smallholder mixed farming systems predominate. Shortage of fodder is the principal problem as a result of decreasing farm size and, as a result, cattle are rarely fed *ad libitum.* Given this constraint, the aim of the PRA was to determine whether farmers employ practices which affect feed utilisation through manipulation of intake and feeding behaviour. The key question asked was, do different farmers with access to the same quantity and type of feed choose to utilise those feeds in different ways?

The design of the PRA study was informed by the results of an earlier, cross-sectional survey of 365 randomly selected farmers in Kiambu District in Kenya (Staal *et al.* 1998). This study identified two groups of resource poor farmers for whom major differences were observed in the use of purchased feeds and milk yield. Six farmers were selected from each of these groups so that equal numbers were represented in cropping systems based on cash or food crops and in female or male-headed households. Seasonal calendars were prepared with farmers and a semi-structured interview carried out to explore current feeding strategies and the rationale behind them. The topics discussed were on and off-farm sources of forage and concentrate and methods of feeding including processing, frequency and timing of feeding, day-to-day fluctuation in fodder use, and within-day mixing of forages and concentrate feeds. Interviews were conducted in the *Kikuyu*, with regular translation allowing participating scientists to clarify conflicting information.

As expected, farmers viewed feed shortages as being most acute during dry seasons. The principal feed used, once the supply of dry maize stover was exhausted and the shortage most severe, was the banana pseudostem. Foliage from fruit trees and hedges were also seen as a last resort, while some farmers purchased cheap concentrates such as maize bran as a fodder substitute. All of the farmers interviewed stated that, even in times of plenty, the amount of feed offered was often inadequate. Feeding strategies varied amongst farms, although this variation could not be attributed to group, cropping system or the gender of the head of household. This may be merely a reflection of the sample size. However, even within such a small group, there was evidence of different strategies to utilise similar resources (Table 1).

Table 1 *Differential utilisation of feed resources by farmers*

Feeding practice	Rationale	Majority of farmers	Unique observations
Treat stover	To ensure minimal wastage	Chopped and soaked with water and salt	Soaked with water and molasses
Divide forage into portions	To ensure some offered at night to avoid behavioural problems	Number of meals decreased as fodder availability decreased	Number of meals increased as fodder availability decreased
Within day mixing	To increase supply and to prevent animals becoming bored	Mix feeds together and allow animals to select	Offer green material first so animal does not waste dry material
Between day fluctuation	None	Dependant on daily activities and opportunities	Variation dependent on availability

The semi-structured interview technique allowed collection of detailed information, difficult to obtain in formal structured surveys, in a manner sympathetic to farmers constraints and objectives. It was clear that farmers thought about the way in which feeds were offered to animals and that strategies differed amongst farms. This would suggest that there may be innovative farmers that can provide some clues to potential solutions constituting the first step in any 'technology trawl'. Although most practices were not aimed at increasing intake, presenting animals with different amounts of feed at different times will inevitably alter feeding behaviour and may have an effect on the efficiency of utilisation of these feeds for production. This finding suggested that focusing the experimental work, described below, on short-term variations in feeding strategies might be more useful as a basis for designing improved feeding strategies than the original narrow emphasis on technologies for manipulating feed intake.

The results of the PRA were used as a basis for designing a longitudinal study of feed resource utilisation conducted over a 15 month period on a subset of the farms that participated in the PRA. Twenty one farmers from Kiambu district agreed to participate in the study. Three major factors, based on identifiable characteristics of the farms and farmers participating in the study, were identified for the analysis of both recorded and derived variables. These were:

- *Land-use classification* Coffee – Dairy zone versus Horticulture – Dairy zone.
- *Labour class*. Households using their own labour *versus* households that were reliant upon hired labour.
- *Season*. Long rain – cool dry – short rain – hot dry.

Collection of data was based around a series of monitoring visits to participating farms by a team of enumerators who were also members of the local extension service. Each farm received a monitoring visit at intervals of approximately 14 days. During the course of each visit, a complete record was made of feeding patterns for the day, of changes in the structure of the livestock holding since the previous visit and of the bodyweights and productive outputs of individual animals.

All of the three main factors strata were found to represent significant sources of variation in the variables studied. Despite the unusual distribution of rainfall over the study period, seasonal impacts on livestock productivity were observed. These were generally manifest in weight and condition score changes rather than reduced or increased milk production, perhaps because of the relatively low mean milk yields (6.7 l day^{-1}) observed. The linkages between these seasonal variations could be clearly attributed to variations in feeding practices, generally with a lag of several weeks. Periods of low rainfall were associated with a subsequent switch from grass-based diets to crop residue-based diets and a greater reliance upon feeds obtained from off-farm. However, offer rates of dry matter

appeared unaffected by these seasonal changes in diet composition.

The main source of labour employed on the farm (household *versus* hired) appeared to exert a wide range of influences on the practical aspects of feeding management. Animals on farms hiring labour appeared to be fed by the same individual much more frequently (87 % of visits) than those on farms using household labour (58 % of visits). Farms employing hired labour also tended to feed at lower offer rates (2.6 *per cent* of BW) than farms that were reliant, principally, on household labour (3.7 *per cent* of BW). Furthermore, overfeeding (allowing animals to select the more nutritious parts of the diet) was also more frequently observed on farms using household labour. These differences were not associated with higher levels of production on the farms using household labour as farms hiring labour appeared to make greater use of concentrate feeds (30 *per cent* of DM fed *vs*19 *per cent* of DM fed).

These findings clearly indicate the need for characterising individual farmers prior to the identification of target interventions. The intricacies of practical feed management on farms in different labour classes is a case in point; illustrating how similar levels of production can be obtained with markedly different feeding strategies. Presumably, encouraging the exchange of elements of the strategies used on the different types of farm could be used as a strategy to enhance the productivity of both.

Effects of Abrupt and Frequent Changes in Type and Quality of Ruminant Feeds

These more strategic activities focussed on the impacts of very short-term variation in feeding practices – a hitherto ignored aspect of feed utilisation in the small-scale livestock production systems found in developing countries.

Two studies were carried out to test the hypothesis that fluctuations in feed supply have a negative effect on performance and to try and understand the underlying mechanisms. Napier grass (*Pennisetum purpureum*) the common fodder in smallholder dairy farms in Kenya, was used to represent good quality feed while barley straw represented poor quality feed.

In a first experiment, the effect of abrupt and frequent changes from napier grass to barley straw on *in vivo* digestibility and live-weight changes of growing dairy cattle was studied. Thirty six growing steers and heifers of Friesian and Ayrshire or their crosses were offered napier grass and barley straw fixed at 90 per cent of the mean *ad libitum* intake on live weight basis in four treatments. These were: 50:50 mixture of napier grass and barley straw, napier grass and barley straw alternated daily, every 5 days or 10 days. Live-weight changes were estimated over 40 days, and digestibility measurements over the last 20 days when the animals had consumed the same amount of napier grass and barley straw on live weight basis, although in different sequences. Live-weight changes were lowest for the animals on a 5 day change over ($p<0.05$). There were no significant effects on intake and *in vivo* digestibility.

Experiment 2 was carried out in two stages. Stage 1 determined the day-to-day variation in rumen ammonia-nitrogen, pH, volatile fatty acids, dry matter disappearance of the ground forage samples in six rumen-fistulated Friesian steers adapted to and fed *ad libitum* napier grass and barley straw at 10 days intervals. Stage 2 determined changes over time during adaptation to the two feeds. Additional parameters considered were microbial nitrogen supply, nitrogen balance and *in vivo* digestibility .

Ruminal ammonia-nitrogen and total volatile fatty acids in Stage 1 were stable for barley straw as intake also tended to be stable but showed day-to-day variation for napier grass that may have reflected changing patterns of intake.

In Stage 2 the rumen dry matter disappearance, ammonia-nitrogen, total volatile fatty acids and microbial nitrogen supply were lower on Day 1 compared to other days for napier grass indicating low microbial activity. The same parameters gradually increased to maximum levels by 3-7 days as the animals adapted to the feed. The urine and faecal nitrogen production gradually increased to a maximum on Day 6 for napier grass and then decreased. As a result nitrogen retention and efficiency of nitrogen utilisation and nitrogen digestibility increased in the second 5 days.

In contrast the rumen dry matter disappearance, ammonia-nitrogen, total volatile fatty acids, microbial nitrogen and efficiency of microbial nitrogen supply in Stage 2 were higher on Day 1 compared to other days for barley straw indicating high microbial activity. The parameters gradually decreased to minimum levels by 3-10 days as a result of decrease in nitrogen intake. Urine and faecal nitrogen production gradually decreased for barley straw in the first 5 days and were stable the second 5 days. As a consequence the nitrogen retention and efficiency of nitrogen utilisation were low in the first 5 days and stable in the second 5 days.

It was concluded that abrupt and frequent changes in the feeding of fixed amounts of napier grass and barley straw would reduce animal performance in terms of growth rate. There was no strong evidence to suggest that intake or *in vivo* digestibility would explain the differences in growth rates between treatments. The slow growth rate of the animals fed on a 5 day change over from barley straw to napier grass appeared to be due to the time required for the rumen microbial population to adapt to napier grass which resulted in low microbial protein supply for growth of the animals and high losses of nitrogen in urine and faeces in the first 5 days compared to the

second 5 days.

On-farm observations in the Kenya Highlands suggest that most resource poor smallholder farmers feed small amounts of concentrates daily to lactating cows regardless of milk yield. Indications are that concentrate supply is not adjusted as the basal diet fluctuates except in extreme cases such as drought when extra feeds such as cereal bran may be given. The results described above suggest that, under these conditions, dairy cows in early lactation, changing the diet from napier grass to barley straw, may be associated with low intake and nutrient density and low milk production. This is because the animals do not recover from restricted feeding in early lactation if high levels are fed in late lactation, even if the total quantity of feed consumed is similar. In the present study live-weight gain when the animals were abruptly and frequently changed from napier grass to barley straw (Experiment 1) was low. Thus if such an abrupt and frequent change from napier grass to barley straw affects live weights it might be expected that milk production which is often the main income source for the smallholder farmers will also be affected.

The Maize Crop as a Feed Source in Smallholder Dairying

Findings of the diagnostic phases of the project appeared to indicate that improvements to feeding practices could be made by closer integration of feeding with other agricultural activities. These studies examined management practices for improving the dual purpose (food – feed) use of the staple maize crop.

As in many of the high potential areas of Kenya, about 80 *per cent* of agriculture-based households in Kiambu District practice intensive, mixed farming. An average farmer in Kiambu District owns 0.8 ha of land, with 0.19 and 0.17 ha respectively dedicated to Napier grass and maize cultivation. He keeps 2.2 cows, which produce 5.8 kg milk/day, fed under a cut-and-carry system. Other farm enterprises in the District include cash crops, mainly coffee and tea, and food and horticultural crops. The high potential areas in the region are subject to increasing population pressure and land holdings which, traditionally subdivided between children, are decreasing in size. Dairying is a financially rewarding enterprise for smallholders. However, meeting the feed requirements of the dairy animals, while maintaining food production from shrinking farm sizes, is already a challenge. Napier grass meets only a modest proportion of the year-long fodder requirement since its actual productivity on-farm is significantly lower than its potential. There are indications that the maize crop will become increasingly important as a source of fodder. This study explored the potential for increasing fodder production on smallholder farms without taking up more land, through the dual-purpose contribution of the maize crop as both food and feed.

The study was divided into three parts. An initial participatory appraisal was conducted in order to overcome the present lack of understanding of the existing maize management practices, and also to investigate the perceptions of farmers with respect to decreasing land sizes. Additionally, the appraisal study gathered views and suggestions on possible modification of existing strategies to increase fodder production from maize. Following this, a series of researcher-designed, farmer-managed experiments was conducted on 6 representative farms to examine seeding rates and manure application, with a view to maximising fodder production from the growing maize crop, without compromising grain yield. Farmers defined seeding and manure application rates (low levels reflecting current farmer practice) and made all decisions concerning subsequent maize management, while the role of researchers was to take quantitative measurements. The experiments were carried out over the short and long rainfall seasons. Finally, farmers again participated in an evaluation of the trials to gather farmers practical experiences with experiments, to determine potentials and problems encountered. Additional information was gathered on maize management practices, which permitted construction of decision-making pathways.

Results indicated that increasing plant density might increase the quantity of good quality fodder produced by the maize crop, depending on the plant density. Grain yield was not affected significantly on most farms, although the cob size was reduced. However there were negative grain yields in cases where there was high plant density, delayed thinning and lack of sufficient rainfall. Practical implications of the study showed that it would be possible to provide maintenance requirements for 34 – 72 days (1 – 2.4 months) in a year, for two cows weighing 350 kg each, from only 0.17 ha of maize. This intervention allowed Napier grass fields time for re- growth and preserved Napier grass for use later where it was ready for harvest, in effect spreading the available feed resources over a longer period of time. It may also reduce the need to purchase fodder off farm and in some cases even to allow farmers to sell excess fodder to neighbouring smallholder farmers to generate additional income.

Dissemination Activities

End of Project Workshop

At the time of writing, the end-of-project workshop is scheduled for early March 2001.

The end of project workshop has been delayed by the fact that some of the trial work has continued until almost the end of the project's lifetime. Furthermore the planned dates have had to be selected to ensure the participation of representatives from all of the project's implementing organisations *and* from the target institutions.

The current proposed format for the end-of project workshop is as follows:

Participation

- Project staff from NRI, KARI, ILRI.
- Staff currently involved in DfID-SDP and associated projects
- Research and extension staff from Tanzania involved in project R6359 and representative of the Dutch government funded Tanga Dairy Development Project
- Representative of DfID Livestock Production Research Programme.
- Representatives of projects currently involved in the dissemination of LPP research in East Africa.

Presentations
Participants will be invited to prepare presentations linked to specific extension messages or technologies. Some, possible examples are:

- Fodder from maize (Ben Lukuyu)
- Desmodium as fodder (David Miano Mwangi)
- Calliandra as a feed supplement (Charles Wambugu)
- Box baling (Nicholaus Massawe)
- How to deal with Napier smut
- Concentrate utilisation (Robert Kaitho / Dannie Romney)
- Utilisation of limited amounts of feed

Participants will be given a prescriptive list of the information required, which would be practically oriented. They would be instructed that presentations should be made as though they were in a 'training of trainers' session directed at extension workers.

Documentation
Each presenter will be required to produce two documents, with a view to these being used directly in SDP dissemination activities.

- A fact sheet / leaflet that would provide all the information required for an extension worker to demonstrate the technology to a farmers and answer any queries that they might have. Information on the expected performance of a technology may include summaries of research results, but in a way that is useful for extension workers and which

illustrate what a farmer might expect from a technology.

- Information aimed at farmers using visual aids as far as possible. This will be based on the one-page format including both pictorial and brief, written information. These leaflets could be distributed at meetings linked with the radio soap opera that SDP is involved in. Presenters will be encouraged to produce more than one leaflet relating to their subject matter rather than one excessively complicated one.

Examples of both formats will be provided for would-be presenters.

In addition, the workshop might also include a farmer field day where some of the presentations could also be delivered to farmers. This would allow them the opportunity to comment on the information given and the leaflets prepared as well as giving them the opportunity to find out about the availability of specific technologies.

List of Dissemination Outputs

To date the project has generated a total of seven published outputs. Further material is in preparation / press.

Romney, D. L., Tanner, J., Chui, J., Kenyanjui, M., Morton, J., Ndegwa, P., Kimari, A., and Thorne, P. (1998) Feed utilisation options for smallholder dairy farmers. Presented at the BSAS Occasional meeting on Foods Lands and Livelihoods, Setting Research Agendas for Animal Science, 2 7-30 January, 1998, Nairobi, Kenya.

Romney, D., Lukuyu, B., Kaitho, R. and Tanner, J. (1999) The maize crop as food and feed. Poster presented at the DFID RNRKS Symposium, Victoria Street, London, December 1999.

Methu, J.N., Romney, D.L., Kaitho, R.J. and Kariuki, J.N. Effects of abrupt and frequent changes in forage quality and the influence of pattern of concentrate feeding on productivity of dairy cattle. First draft prepared for submission to the 3rd All Africa conference on Animal Agriculture to be held in Alexandria, Egypt, 6-9 November 2000.

Sanda, I.A., Romney, D.L. Tanner, J.C., Thorne, P.J. and Leaver, J.D. The effect of abrupt and frequent changes in forage quality on digestibility and performance of crossbred cattle offered Napier grass (*Pennisetum purpueum*) and barley straw. First draft preparedfor submission to Animal Science.

Lukuyu, B.A., Romney, D.L., Tanner, J.C. and Thorpe, W. The maize crop as a source of food and feed for livestock on smallholder dairy farms in the Kenyan highlands. Abstract accepted for the 2000 BSAS winter meeting.

Sanda, I.A., Romney, D.L., Tanner, J., Thorne, P. and Leaver, J.D. The effect of abrupt and frequent changes in forage quality on nitrogen balance in crossbred steers fed napier grass (*Pennisetum purpureum*) and barley straw. Abstract accepted for the 2000 BSAS winter meeting.

Sanda, I.A. (1999) The effect of abrupt and frequent changes in type and quality of forage feed offered to ruminants on nutrient utilisation. MPhil thesis, Wye College, University of London.

Further Research and Dissemination Required

The project was designed to integrate with the developmental activities of the SDP in Kenya.

The end-of-project workshop will ensure that there is a proper "hand-over" of findings so that these may, where appropriate, inform the activities of the SDP.

Further research activities that will address some of the issues raised by the current project will be accommodated by a new, LPP project (R7459)

entitled *Development of Seasonal Nutrition and Resource Management Strategies for Smallholder Dairy Systems.* This new project involves collaboration amongst the University of Edinburgh, the Natural Resources Institute and the International Livestock Research Institute and aims to integrate the findings of the current, and a number of other projects into suites of "best-bet" management options for small-scale dairy farmers.

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