Sustainable Feed Production and Utilisation for Smallholder Livestock Enterprises in Sub-Saharan Africa

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Edited by:
Jean Ndikumana and Peter de Leeuw

African Feed Resources Network (AFRNET)
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Preface

Increasing intensification and efficiency in the use of available feed resources represents one of the most important strategies to improve the productivity of animal agriculture in the developing world. In 1991, ILCA (and now ILRI) initiated the African Feed Resources Network to strengthen the capabilities of national agricultural research institutions and scientists to conduct research on feed resources development and utilisation through collaborative research, training, dissemination and exchange of information. The network turned into an efficient forum through which sub-Saharan African animal nutritionists, forage agronomists and other stakeholders shared information on research methodologies and available technologies to develop sustainable livestock production systems in sub-Saharan Africa.

It is within this context that after two years of activities, AFRNET organised its second Biennial Conference at Harare, Zimbabwe, on the theme "Sustainable feed production and utilisation for smallholder livestock enterprises in sub-Saharan Africa" as an opportunity for collaborative scientists and other partners to discuss research results and identify new technologies/opportunities for better development and utilisation of feed resources in the major ecoregions of tropical Africa.

The workshop was attended by 60 participants from 21 sub-Saharan African countries as well as by scientists from ILCA, NRI, CIRAD and SIDA. Six farmers representing small and medium-scale livestock producers also attended the workshop.

The geographical distribution of the presented papers was well balanced: of the 33 contributions 41 were generated by scientists from West and central Africa, 41% from East Africa and the remainder from southern African countries, mainly from the host country Zimbabwe

Six papers reported on the evaluation of forage crop germplasm in projects partially funded by the Feed Resource Network. Another four contributions dealt with issues of forage crop production. Animal-based evaluation of forages and rations was covered by two-thirds of the papers. Among these, three papers assessed forage conservation through ensiling and hay-making. In feeding trials, supplementation with browse, planted herbaceous of shrubby legumes was a common theme, while supplementation of dairy calves and cows was a priority area of Kenyan scientists. Similarly, increasing the milk production of dairy goats through better feeding was covered in three papers. In contrast to the previous workshop held in Botswana in 1991, where 11 papers were presented under the heading of "Integrated Feed Resource on Farm", only one paper focused on this issue.

Acknowledgements

The African Feed Resources Network (AFRNET) is grateful to the International Development Research Centre (IDRC) and to International Livestock Centre for Africa (ILCA) for their strong technical and financial support of AFRNET activities, including sponsoring the organization of this workshop and the publication of the proceedings. This workshop would not have materialised without the full commitment and dedication of AFRNET collaborating scientists and their institutions. To all of them, the network is very grateful.

Many people made valuable contributions to the production of these proceedings. Special thanks are due to Miss Josephine G. Njuki, AFRNET Secretary, as well as to Mrs Rose

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The Editors.

Opening address

S.S. Mambo

Deputy Secretary for Lands, Agriculture and Water Development, Zimbabwe

Mr. Chairman, Distinguished Delegates, Ladies and Gentlemen:

I feel greatly honoured to have been invited to open this workshop for the African Feed Resources Network on the theme "Sustainable Feed Production and Utilisation for Smallholder Livestock Enterprises in sub-Saharan Africa".

On behalf of the Government of Zimbabwe and on my own behalf, I would like to thank the AFRNET Steering Committee for deciding to hold this workshop in Zimbabwe. I am glad to note that the workshop has drawn participants from across the African continent as well as from a number of other International Organisations. I believe that this rare gathering will give each one of you a unique opportunity to particularly warmly welcome all foreign participants to Zimbabwe. It is my sincere hope that you will find your stay comfortable and also that your programme will allow you some time to see and learn more about Zimbabwe.

Mr. Chairman, I believe I do not need to remind this audience of the seriousness of the food crisis facing Africa. I note that you specifically have focused on the smallholder livestock producer in Africa. You are all aware that livestock productivity in sub-Saharan Africa is very low and that per capita consumption of animal products is also very low, compared to world standards. Your network has identified feeding as a major constraint facing livestock industry in Africa. Your network has also set as its major objectives:

a) To promote research among participating institutions and catalyse applied feed research initiatives for the improvement of relevant crop–animal systems

b) To promote exchange of information among animal scientists working on feed resources and disseminate information on the utilisation of forages, crop residues and agro-industrial by-products in sub-Saharan Africa.

I am pleased to note that in order to achieve these objectives you as African scientists realised the need to cooperate and collaborate and hence the formation of your collaborative research network. The desire to overcome isolation, the desire to learn from others working in the same area, the desire for a forum through which scientists can communicate with policy makers, and a likelihood of getting financial support, I am told were the driving forces towards the formation of your Pan-African Animal Feed Resources Network.

It is my sincere hope that in focusing on the smallholder farmer, you do have the farmers in your minds and hearts. If farmers are not involved or consulted in determining research priorities, resources may be wasted with no impact as farmers may stay away from utilising research results.

At this particular time it is very necessary for researchers to consider seriously the development of applied research. African scientists should utilise existing knowledge from basic research to develop appropriate problem-solving projects. I would like to stress that solutions for African agricultural constraints must be found within Africa and not from outside Africa. Effective crop and livestock production strategies for the diverse ecological and farming systems in Africa cannot be prepared from results of intensive long-term research on agricultural production constraints. I know and appreciate that it is possible to adapt some existing technology from elsewhere. Nevertheless, I would like to stress that much of the knowledge needed for agricultural production in Africa is likely in some instances to be location specific and in such cases technology to solve existing problems must be generated locally. If your network has focused on the smallholder livestock farmer, then I strongly believe that we should not spend too much time trying to re-invent the wheel, but rather we should utilise the wheel in carrying out various functions for the African farmer.

With these few remarks, Mr. Chairman, it is now my honour to declare this workshop officially open.

Key issues for sustainable feed production and utilisation for smallholder livestock enterprises in sub-Saharan Africa

L.R. Ndlovu

Faculty of Agriculture, University of Zimbabwe
P.O. Box MP 167, Harare, Zimbabwe

Abstract

The increased human population in Sub-Saharan Africa requires that research in feed production and utilisation is intensified to ensure adequate supply of food of animal origin. We need to develop principles and strategies that maintain a balance between protection of the natural resource base and the exploitation of this base for food production. Smallholder farmers have limited resources and for any sustainable intervention, their objectives must be central to the solutions suggested. Farmers must be equal partners in our research and their knowledge of production systems should be integrated into our modern theoretical concepts. Gender and policy are also critical to sustainability.

Introduction

In less than 10 years, the human population of sub-Saharan Africa is expected to increase by 176 million people (Winrock International 1992). This will aggravate the food deficiency in the region—particularly food of animal origin. Whilst it has been argued in certain quarters that animal production is an inefficient way of supplying essential nutrients to humans, the fact remains that foods of animal origin are still preferred by the majority of people. The challenge to scientists is therefore how to meet the expected rise in demand for livestock products.

The theme of this workshop further challenges us not only to meet this demand but also sustain the increased productivity. What is sustainable feed production and utilisation? It is the management and conservation of land, water, plant and animal genetic resources in a manner that ensures attainment and continued satisfaction of the need for livestock feed for present and future generations. The technologies used must be environmentally non-degrading, technically appropriate, economically viable and socially acceptable.[1] How can this ambitious goal be achieved? First and foremost we must recognise that this idea serves as a guide for the design of policies and strategies for sustainability and may not be achieved in its entirety at all times. The definition gives equal importance to ecological, agronomic, economic and social issues. This is important in the light of current discussions which sometimes argue for the supremacy of ecological issues over all others. Agriculture performs a vital public function—that of feeding people and to do this it must make use of natural resources.

1. Paraphrased from the FAO 1988 definition of sustainable agriculture.

We need to develop principles and strategies that can maintain a balance between ecology and productive capacity of natural resources without creating a conflict between us and nature. It is imperative that we determine thresholds of tolerance for exploitation of natural resources for agricultural productivity in an endeavour to feed our populations.

Of direct importance to this workshop is the sustainability of feed production and utilisation in smallholder farming systems. Let us look at some characteristics of this sector. Typically, the farmer has a small land area for cropping, uses family labour for almost all agricultural tasks, has limited resources (cash, land, labour etc) and often runs an integrated crop–livestock system. Each farmer has specific objectives for his enterprise; these could vary from the subsistence supply of household food to more financial objectives (employment, income generation etc). For any sustainable intervention, the farmer's objectives must be central to our strategy.

Strategies for feed production

The farmer's objectives interact with other factors in the system. Within our context, I have chosen feed resources and animal requirements. Feed resources are a function of available land and its resource, the genetic potential of available plant material and the supply of other inputs. The land resource base is influenced by ecozone. Five such zones are generally recognised: arid, semi-arid, subhumid, humid and highlands. Suffice to say at this stage that different strategies are required for each ecozone. Animal requirements are influenced by type of product and among other things, by what the farmer wants to achieve: i.e. his production goals. So what strategies can we develop that optimise natural resource utilisation without degrading the environment? First let us consider the animal factors. They include requirements for major metabolites, factors affecting voluntary feed intake and the type of animal. These factors will influence our strategies which differ for each ecozone. I will give a synopsis of some possible strategies for each of the zones.

Arid

The main constraint is the inadequate overall supply of feed which is exacerbated by seasonal shortages. Possible strategies include:

- management of livestock such that their peak nutritional requirements coincide with periods of adequate feed availability
- identification of low cost systems of grazing management that emphasise social institutions to control land use and protect natural resources
- breeding/selection of forages with higher water-use efficiency
- utilisation of indigenous browse trees.

Semi-arid

The main constraints are low protein and energy content and seasonal fluctuations in supply of nutrients. Possible techniques for ameliorating the situation include:

- utilisation of droughts tolerant fodder trees and optimal use of indigenous browse species as fodder
- improvement of seed production of suitable fodder plants
- reseeding of degraded pasture areas and introduction of local management systems to properly use communal rangelands.

Subhumid/humid

The constraints mainly relate to the proper distribution of feed supplies across time. Since in the wet seasons, supplies outstrip demand, there is a need for conservation of feed to achieve an adequate year-round supply. Thus, technologies for preservation and storage of feed are required. Other strategies include:

- improved use of crop residues and low quality forages together with protein supplementation from legume forages, grown on farm
- agroforestry techniques (alley-cropping, hedges etc) that are adapted to multiple usage including grazing and cut-and-carry for feeding livestock, and mulching to maintain soil fertility.

Highlands

High rural population and livestock densities require high yielding short-cycle forages so that several harvests can be obtained per year. At the same time, technologies for preserving and storing forage supplies should be developed.

Other strategies

For any of these strategies to have an impact, farmer participation must be an integral part of the research that develops these technologies. Farmers must be seen as equal partners and the selection of "best-bet" technologies must take into account criteria that are important to farmers. Forages demanding high labour inputs to produce high yields are unlikely to be adopted. Many feed evaluation studies place emphasis on animal growth performance, which may be of minor importance to farmers who need draught power and milk.

In addition to farmer participation in research we need to consider their indigenous knowledge and technologies; local knowledge forms the basis for a host of activities pertaining to agriculture and environmental conservation. Typically, this knowledge has accrued over several generations and is often passed on verbally; research project planning can therefore greatly benefit from the accumulated knowledge of local circumstances and environment, and should promote its integration into protocol preparation.

Our research should also take into account the specific gender roles in the communities we work in. Strategies that result in shifting the labour burden to women but leaving the benefits in the pockets of men will not be adopted or, if adopted, will not be sustained. Additionally, different age/sex groups in rural households are custodians of specific indigenous knowledge; thus taking cognisance of gender issues will ensure that our research does not conflict with established community norms.

Finally, as researchers in livestock feed production and utilisation we need to be involved in promoting policies that provide an enabling environment to smallholder farmers. Pricing and marketing policies often have great impact on the adoption and sustainability of agricultural interventions. However, in view of the recent emphasis on environmental conservation it is essential that the means of production of smallholders are not sacrificed on the altar of political correctness.

References

Winrock International. 1992. *Assessment of Animal Agriculture in Sub-Saharan Africa.* Winrock International Institute for Agricultural Development, Morrilton, Arkansas, USA. 125 pp.

Les principaux facteurs de la production et de l'utilisation durables des aliments du bétail dans les petites exploitations agricoles d'Afrique sub–Saharienne

Résumé

Compte tenu de la croissance démographique de l'Afrique subsaharienne, la recherche sur la production et l'utilisation des aliments du bétail doit s'intensifier pour assurer un approvisionnement adéquat en produits alimentaires d'origine animale. Il importe de développer des principes et des stratégies appropriés en vue de maintenir l'équilibre entre la protection de la base des ressources naturelles et l'utilisation de celle-ci pour la production alimentaire. Les ressources des petits exploitants agricoles étant limitées, toute intervention durable doit tenir dûment compte de leurs préoccupations. Les paysans doivent être des partenaires à part entière des efforts de recherche et leur connaissance des systèmes de production doit être intégrese à nos concepts théoriques modernes. Par ailleurs, les spécificités liées au sexe et les politiques de production sont également des paramètres critiques de la durabilité des systémes de production.

Evaluation of Forage Crop Germplasm

Evaluation of herbaceous legume germplasm for coastal lowland East Africa

M.N Njunie[1], L. Reynolds[2], J.G. Mureithi[1] and W. Thorpe[2]

[1]Kenya Agricultural Research Institute (KARI), Regional Research Centre, Mtwapa
P.O. Box 16, Kikambala, Kenya
[2]International Livestock Centre for Africa (ILCA), KARI/ILCA, Collaborative Programme
P.O. Box 80147, Mombasa, Kenya,

Abstract

Herbaceous legume germplasm comprising 62 accessions of 18 species were selected for their potential suitability to tropical coastal lowland environments and were evaluated in three agro-ecological zones (AEZ) of Kenya's coastal lowlands. Three accessions were local genotypes with proven productivity, whereas the other 59 were received from ILCA's genebank. The AEZs were the coconut/cassava zone (semi-humid with "high" annual rainfall: 1050–1230 mm); cashewnut/cassava zone (transitional, "medium": 920–1000 mm); livestock/millet (semi-arid, "low": 800–900 mm). At each site rainfall is bimodal. Soils at the evaluation sites are sandy, low in organic matter and plant nutrients. The herbaceous legumes were assessed for the effects of harvesting at 3, 6, 9 and 12 months after planting on productivity and survival. Harvesting either once, twice, thrice or four times within the year from date of planting was also evaluated.

Germination was generally good (over 60%) for most accessions at all sites. At the semi-humid site, dry matter (DM) production increased progressively in each delay of the first cut in contrast to the semi-arid site where the changes in DM production were less pronounced. DM yields from the semi-humid site averaged 0:24, 0.54, 0.56 and 0.71 kg/metre row (kg/m) for harvesting after 3, 6, 9 and 12 months following planting. The species that showed high persistence at both semi-humid and semi-arid sites included *Macroptilium atropurpureum, Clitoria ternatea, Centrosema pubescens, Neonotonia wightii* and *Macroptilium lathyroides. Pueraria phaseoloides, Galactia striata* and *Centrosema arenarium* showed persistence under frequent harvesting in the semi-humid site, while only*Centrosema virginianum* was persistent at the semi-arid site.

Generally, plots that were harvested four times per year gave the highest cumulative DM yields. At the "high" rainfall site, the mean yields for the 12 most persistent and highest yielding selections were 1.34, 1.25, 1.10, 0.71 kg DM/m for four, three, two and one cut(s), respectively. At the semi-arid site cumulative DM yield was on average 60% lower and the dry season yields were about 25% less than the other harvests due to heavy leaf drop. At the "medium" rainfall site, establishment of most legumes was poor as they were sown towards the end of the rainy season. In terms of plot cover and survival five accessions of *Clitoria ternatea* were amongst the seven best performing legumes.

For coastal lowland East Africa, *Macroptilium atropurpureum* and *Clitoria ternatea* are among the most productive herbaceous legumes. Good performance of *Lablab purpureus, Macrotyloma axillare*and *Calopogonium mucunoides* during early cuts indicate that a range of herbaceous legume germplasm is available that may require further testing in agronomic

experiments on inter-, and relay-cropping and in studies of nutritive value as feeds and resulting livestock performance.

Introduction

The agricultural productivity of coastal lowland East Africa is limited by farming systems which are dependent on soils deficient in nitrogen and yet utilise few purchased inputs. Forage legumes can make a significant contribution to resolving these problems (Haque et al 1986). Studies on the integration of legumes into the local farming systems have been restricted mainly to leguminous shrubs such as *Leucaena leucocephala* (Jama 1988; GASP 1990; Jama et al 1991; Mureithi 1992). However, fodder productivity in livestock systems can also be improved through the utilisation of herbaceous legumes (Njunie and Ogora 1991; Mureithi 1992; Mureithi and Thorpe 1993).

To investigate the potential of herbaceous legumes, a systematic programme was started in 1990 as part of the collaboration between the Kenya Agricultural Research Institute (KARI) and the International Livestock Centre for Africa (ILCA) (Thorpe et al 1993). The objectives were first to screen herbaceous legume germplasm selected from the ILCA genebank, and secondly to test the most promising accessions for specific roles within the region's farming systems. Regional evaluations of herbaceous legumes identified *Clitoria ternatea* and *Macroptilium atropurpureum* as the most promising herbaceous legume species (FAO 1981). However, this evaluation did not extend to agronomic assessment within production systems. The research presented here was undertaken to identify herbaceous legumes further for on-farm testing.

Materials and methods

Sixty-two accessions of 18 herbaceous legume species were selected for the programme. Fifty-nine were selected by ILCA genebank scientists based on the recorded suitability for tropical coastal lowlands with medium (800–1300 mm) annual rainfall. Three local accessions with proven high productivity were included (Table 1).

Table 1. *The herbaceous legume species and accessions evaluated at the three sites in the coastal lowland of Kenya and their ILCA code numbers.*

Species	ILCA accession no.
Calopogonium mucunoides	540, 6750
Centrosema arenarium	12451, 12451
Centrosema pubescens	137, 152, 219, 232, 9051,*
Centrosema virginianum	507, 512, 6768, 7003, 7259
Clitoria ternata	6767, 7261, 9282, 9291, 15435, **
Desmodium adscendens	100, 12450
Desmodium canum	6991, 9923, 10858
Desmodium sandwicense	6990
Desmodium uncinatum	6765
Desmodium intortum	101, 6851
Galactia striata	12424, 12425

Lablab purpureus	147, 6529, 11609
Pueraria phaseoloides	156, 544, 15586, 10254, 10588
Macroptilium atropurpureum	69, 112, 385, 389, 392, 393, 397, 12391, 14556, ***
Macroptilium lathyroides	9275
Macrotyloma axillare	1138, 6756, 6959, 14988
Neonotonia wightii	6761, 6762, 9633, 9755, 9794, 10230
Vigna caracalla	11057

* A local accession (uncoded) was planted as a control at Mariakani only.

** A local accession (MP009) was planted as a control at Mtwapa, Mariakani and Msabaha.

*** A local accession (MP015) was planted as a control at Mtwapa, Mariakani and Msabaha.

The accessions were planted

- on 18 June 1991 at Mtwapa (3°56'S; 39°44'E and 15 m a.s.l.) in the coconut/cassava (CL3) agro-ecological zone (semi-humid with "high" annual rainfall: 1050–1230 mm);
- on 24 July at Msabaha (3° 16'S; 40°03'E and 12 m asl, "medium" rainfall: 920–1000 mm);
- on 24 June at Mariakani (3°53'S; 39°28'E and 204 m asl) in the livestock/millet CL5 zone (semi-arid, "low" rainfall: 800–900 mm)

The accessions were evaluated through assessing the effects of harvesting at three, six, nine and 12 months after planting on their productivity and survival.

Harvesting either once, twice, thrice or four times within the 12-month growing period was also evaluated. Records were kept of dates to flowering, podding, plot cover, leaf fall, pest and disease attack. Seed yield was recorded on the uncut portions of the plots.

The agro-ecological zones have been defined by Jaetzold and Schmidt (1983). At each site rainfall falls in a bimodal distribution. Mtwapa, Msabaha and Mariakani are research centres of the Kenya Agricultural Research Institute. Soils of these centres as described by Siderius and Muchena (1977), are generally sandy and low in organic matter and plant nutrients. At Msabaha, the dominant soil was classified as Orthic Ferralsols and is similar to soils at Mtwapa except that they are brown friable sandy clay foams. At Mariakani Orthic Solenetz prevails, which is moderately well drained, very deep, yellowish brown, friable to firm sandy clay loam to sandy clay.

Each accession was planted in single rows, each 5 m long and 1.5 m apart, and replicated four times. A 0.5 m length at the end of each row acted as a guard area. After scarification and treatment with inoculum supplied by ILCA for each accession, the seeds were drilled in a well-prepared seed-bed. One month after establishment, triple superphosphate (TSP) fertiliser was applied on either side of the legume rows at a rate of 20 kg P per hectare.

During the fourth week after planting, emerging plants were counted from each row plot to assess germination rate. Standards to describe uniformity of plant emergence were set for each species according to the size and quantity of seed planted. Row cover was recorded on a scale of 1–10, in which 1 represented 10% or less of a row covered by germinating plants and 10 meant a uniform dense cover.

Plant-vigour scores on a 1–10 scale visually compared the growth of the plants of each accession with that of neighbouring plants of other accessions. High scores meant that the plants were growing rapidly. Leaf-drop scores (scale 1–10; 10 was high) were obtained by observing amount of leaf on the ground under the plant as compared with that observed for neighbouring plots of other accessions.

Dates of the first and subsequent fully opened flowers were recorded. Plant counts recorded during the first month of establishment were used as a basis for the calculation of dates of 10% and 50% flowering and end of flowering. To record pod development, the dates of first full grains, maximum full grains and first shattering were recorded but are not reported in this paper.

To measure dry matter (DM) production and its seasonality, forage was harvested from four one-metre row portions. Each portion was harvested at different intervals and varying frequency as follows: cuts of one-metre row lengths started three months after planting to include the growth in the long rainy and short dry seasons; another section of the row was cut six months after planting, during the short rainy season.

During the second cut, the regrowth from the first cut was also harvested and the weights recorded separately. The third cut was carried out nine months following planting during the second long dry season, and included the regrowth from the first cut and second cut portions; the fourth cut was made one year after planting during the long rainy season. It included the regrowth of all previously cut portions with the weights of each section recorded separately. During each harvesting, 200 g was sampled from each portion and dried at 105°C to constant weight for the estimation of dry matter production.

The results are presented as means at each site for the four replicates of each accession, based on observations carried out on plot cover, plant vigour, and leaf drop up to three months after planting. Dry matter yields per metre row (kg/m) were estimated at Mtwapa and Mariakani, from four harvests carried out from late September, 1991 to middle of June, 1992. Score data are presented as either good (score$\geq$ 7), average (score 4–6) or low (score$\leq$ 4).

Results

Semi-humid site (Mtwapa)

Establishment

Establishment was generally good, with half the accessions scoring $\geq$7 for row plot cover during the first month after planting, while only few (8%) had low scores$\leq$ 5. The growth was slow during the first two months (68% with scores 5–6). During the third month there were clear differences in plant vigour with 21 (33%) of the accessions having high vigour (scores $\geq$7). These were (in descending order): *Lablab purpureus* ILCA nos. 11609, 6529 and 147; *Clitoria ternatea* 9291, 9282, 7261, 6767, 15435 and control (MP009); *Neonotonia wightii* 9633; *Macrotyloma axillare* 1138, 6756 and 149;*Macroptilium atropurpureum* 392 and 69; *Macroptilium lathyroides* 9275; *Calopogonium mucunoides* 540; *Pueraria phaseoloides* 156 and 15586; *Desmodium uncinatum* 6765; and *Centrosema pubescens* 152.

Forage dry matter production

Eight species and 28 of their accession numbers yielded high DM (above 0.2 kg/m) and were persistent under the most frequent harvesting regime (Table 2). The DM yields for initial harvests of the most productive and persistent species and accession numbers are presented in Table 3.

Table 2. *The mean dry matter production from frequent harvesting imposed on the 28 herbaceous legume accessions which persisted during twelve months after planting at a semi-humid site of Mtwapa in coastal lowland Kenya.*

Species	Accession n° [1]	kg DM/m	
		Mean	Range
Pueraria phaseoloides	544, 156	0.58	0.71–0.45
Centrosema pubescens	219, 9051, 232, 152, 137	0.43	0.49–0.37
Macroptilium atropurpureum	12391, 397, 112, 393, 392	0.41	0.62–0.21
	389, MP015, 69		–
Macroptilium lathyroides	9275	0.40	0.45–0.30
Neonotonia wightii	6762, 10588, 9755	0.40	0.47–0.21
Clitoria ternatea	9291, 9282, 7261, 14435	0.33	
	MP009, 6767		
Galactia striata	12425	0.30	–
Centrosema arenarium	12451	0.22	–

1 Arranged in descending order (left to right) of DM production.

Table 3*. Dry matter yields (kg/m) for initial harvests taken 3, 6, 9 and 12 months after planting of herbaceous legume accessions selected for their persistence and DM production at the semi-humid (Mtwapa) site.*

Species	Acc. No.	Months to initial harvest following planting				Mean
		3	6	9	12	
Macroptilium atropurpureum	392	0.32	0.71	0.85	0.96	0.64
M. atropurpureum	397	0.23	0.53	0.79	1.02	0.64
M. atropurpureum	12391	0.24	0.63	0.65	0.93	0.61
M. atropurpureum	MP015	0.23	0.77	0.67	0.60	0.56
M. atropurpureum	393	0.22	0.49	0.74	0.71	0.54
Centrosema pubescens	219	0.16	0.56	0.53	0.87	0.53
C. ternatea	9291	0.41	0.53	0.43	0.75	0.53
Pueraria phaseoloides	156	0.24	0.48	0.33	0.57	0.53
C. pubescens	9051	0.16	0.38	0.86	0.70	0.52
C. ternatea	MP009	0.31	0.53	0.25	0.60	0.43

P. phaseoloides	544	0.26	0.43	0.26	0.55	0.38
Neonotonia wightii	6762	0.12	0.46	0.32	0.55	0.36

SE means of initial harvest (H) 0.028; SE means of accessions (A) 0.048; SE means H*A 0.096.

Forage dry matter from initial cut

Dry matter production varied with the period from planting to initial cut (P<0.05). The mean yields were 0.24, 0.54, 0.56 and 0.71 kg/m for the initial harvests at 3, 6, 9 and 12 months, respectively. There were significant differences between cuts (P<0.05). The top 14 performers for the earliest cut (3 months after planting) were, in descending order: *Lablab purpureus* 6529, 147 and 11609;*Macroptilium lathyroides* 9275; *Clitoria ternatea* 9291, 7261, 6767, 9282 and the control MP009; *Macroptilium atropurpureum* 392; *Macrotyloma axillare 1138 and 6756; Centrosema pubescens 152; and Calopogonium mucunoides 540.*

Effect of number of harvests per year on forage dry matter production

More frequent harvesting was associated with higher DM yields (Table 4). Mean yields for the 12 persistent and highest yielding accessions ranged from 0.71 to 1.34 kg/m. Seven of these 12 top ranking legumes were accessions of *Macroptilium atropurpureum.*

Table 4. *Mean cumulative dry matter yields for one year's growth of herbaceous legume accessions selected for persistence and high dry matter yield at the semi-humid (Mtwapa) and semi-arid (Mariakani) sites in coastal lowland Kenya*.

Growth period to initial harvest and number of harvests	Yield (kg DM/m)
Semi-humid (*Mtwapa*)	
Three months: three harvests	1.34
Six months: two harvests	1.25
Nine months: one harvest	1.10
Twelve months: one harvest	0.71
Semi-arid (*Mariakani*)	
Three months: three harvests	0.53
Six months: two harvests	0.52
Nine months: one harvest	0.46
Twelve months: one harvest	0.46
SE semi-humid site	0.043
SE semi-arid site	0.026

Their forage production based on four cuts ranged from 1.72 kg/m obtained from ILCA accession number 12391 to 1.14 kg/m from a locally grown variety (MPO 15). Others were *Pueraria phaseoloides* 544 (1.60 kg/m); *Clitoria ternatea* 9291 (1.39 kg/m); and *Centrosema pubescence* 219 and 9051 (mean yield 1.25 kg/m).

Leaf drop

About 50% of the accessions showed some leaf drop three months after planting. Significant leaf drop (score ≥4) was recorded for, in descending order: *Clitoria ternatea* 9291, 9282 and 15435;*Macrotyloma axillare* 6756, 1138, 6959 and 14988; *Lablab purpureus* 11609, 6529 and 147; *Macroptilium atropurpureum* 12391 and 112 and *Centrosema virginianum* 7003.

Semi-arid site (Mariakani)

Establishment

Establishment was generally good despite the heavy rains that followed planting. Most of the accessions (50%) established well (score≥7). During the second month following planting several accessions exhibited good growth (score≥7). These were (in descending order): *Lablab purpureus* 11609, 6529 and 147; *Macroptilium atropurpureum* 392, 12391, 397, 393, 112, and 389; *Clitoria ternatea* 9291, 15435, MP009 (control) and 7261; *Macroptilium lathyroides* 9275; *Desmodium sandwicense* 6990; *Centrosema virginianum* 512; and *Macrotyloma axillare* 1138. Out of the 60 accessions established, 27 persisted even when subjected to the most frequent harvesting (Table 5).

Table 5. *Mean dry matter production (kg/m) of persistent herbaceous legume species and their accession numbers from most frequent harvesting imposed during twelve months after planting at a semi-arid (Mariakani) site in coastal lowland Kenya.*

Species	Accession no.[1]	Mean	Range
Macroptilium atropurureum	397, 389, 385, 12391, 392, 69, 112, 393	0.41	0.53–0.26
Clitoria ternatea	15435, 9291, MP009, 6767, 7261, 9282	0.30	0.35–0.25
Centrosema pubescens	152, 219, 232, 137, 9051, *	0.28	0.34–0.24
Neonotonia wightii	6762, 9755, 10588, 6761	0.29	0.41–0.21
Macroptilium lathyroides	9275	0.26	–
Centrosema virginianum	6768, 507	0.22	0.24–0.20

* Local accession of C. *pubescens,* uncoded.

[1] Arranged in descending order (left to right) of DM production.

Forage dry matter production

Forage dry matter from the initial cut

The overall mean yields were 0.07, 0.12, 0.08 and 0.46 kg/m for initial harvests at 3, 6, 9 and 12 months, respectively. The yield after nine months' growth was 25% lower than the preceding yield because it was carried out during the long dry season when heavy leaf fall was recorded. *Lablab purpureus* (11609, 6529 and 147), *Macroptilium atropurpureum* (392 and MP015), and *Macrotyloma axillare* (6959) produced the most DM from early cutting. When the initial cut was delayed, *Centrosema* species (137, 152, 12451, 9051), *Galactia striata* (12425) and *Clitoria ternatea* (9291, 9282) performed best.

Effect of number of harvests per year on forage dry matter

Number of harvests did not influence annual dry matter yield (Table 4). The DM yields recorded ranged from 0.53 kg/m from most frequently harvested to 0.46 for least frequently harvested rows. The highest overall mean yields from the persistent and high yielding accessions was 0.60 kg/m (achieved in three cuts) recorded from *Neonotonia wightii* 6762, *Macroptilium atropurpureum* 392, 393 and 389; other *M. purpureum* accessions produced 0.5 kg/m (112, 12391 and 69). Two accessions of *Clitoria ternatea* (9291 and 15435) produced 0.5 kg/m and one accession of *Centrosema pubescens*(152) produced 0.4 kg/m.

Leaf drop

Data collection was hampered by heavy showers which washed away fallen leaves from the sloping site. Appreciable leaf fall was recorded for *Clitoria ternatea* 6767 and 15435; *Macroptilium atropurpureum* 397; *Lablab purpureus* 147 and 11609.

Transitional site (Msabaha)

Establishment

At the Msabaha site, planting was done one month later than at the other sites due to poor rainfall. Of the 59 accessions planted, 31 survived the immediate stress caused by the lack of soil moisture. Seven accessions established well (score ≥7), in descending order: *Clitoria ternatea* 9291, 6767, 15435 and 9282; *Lablab purpureus* 6529 and 147; and *Macroptilium atropurpureum* 392. Growth was most vigorous (score≥ 7) for *Lablab purpureus* (6529 and 147) and *Clitoria ternatea* (9291, 9282 and 6767).

Leaf drop

By the end of the third month, leaf drop was most noticeable (score ≥4) for *Macroptilium lathyroides* (9275), *Lablab purpureus* (6529) and *Macroptilium atropurpureum* (MP015, 397 and 392).

Discussion and conclusions

This study evaluated a wide range of accessions and species which differed in growth habit, DM production and persistence when subjected to frequent harvesting.

At the semi-humid site, 28 accessions from eight species persisted despite having been subjected to the frequent harvesting. At the semi-arid site, there were 27 persistent accessions from six species. The large number of persistent accessions suggests that there is a range of species and accessions able to withstand the harvesting practices observed in small holder farms, which generally involve continuous harvesting of forage to feed livestock. The eight species that showed persistence at the semi-humid site included Clitoria ternatea Acc. no. MP009 and *Macroptilium atro-purpureum*Acc. no. MP015; the two species recommended from past studies (FAO 1981). The other accessions included ILCA no. 9281 and 9282 of *Clitoria ternatea* and ILCA nos. 392 and 397 of *Macroptilium atropurpureum.* These two species have been evaluated in semi-humid forage production systems as intercrops of *Pennisetum purpureum* (Napier grass) (Mureithi and Thorpe 1993) and in semi-arid coastal lowlands as intercrops with *Chloris gayana, Panicum maximum* and *Cenchrus ciliaris* (Njunie and Ogora 1991). Due to its climbing habit, *Clitoria ternatea* mixes well with grasses and is therefore the recommended herbaceous forage legume species for smallholder dairy farmers in CL3, CL4 and CL5 AEZs in the coastal lowlands.

Mureithi and Thorpe (1993) reported that *Macroptilium atropurpureum* Acc. no. MP015 did not persist as an intercrop with *Pennisetum purpureum* when frequently harvested. During the current study,*M. atropurpureum* accessions produced large amounts of dry matter and were persistent when frequently harvested. There is a high probability that the accession ILCA no. 392 that was ranked amongst the highest DM producers may be a promising alternative to the currently recommended local accession. It is also likely that the cutting intervals employed were long enough to favour *M. atropurpureum* species. Humphreys (1978) has reported that this species is more persistent under long (three months) harvesting intervals. The cutting height (15 cm above ground level) was considerably higher than the cutting height of 3.75 cm which led to the lack of persistence of *M. atropurpureum* reported by Skerman et al (1988). The good performance in this study suggests that it would be useful to reassess the contribution this important species can make to the coastal lowland farming systems. It is worth noting that *Macroptilium atropurpureum* was compatible in mixture with important coastal lowland grasses like *P. coloratum, Panicum maximum* and *Chloris gayana* (Whiteman 1980), making it a valuable forage legume. It has been observed to perform moderately well under the shade of coconut trees, an important tree crop in the coastal lowlands of East Africa (Reynolds 1988).

Another species that showed good adaptability is *Centrosema pubescens.* Six accessions including the local accession (uncoded) from Mariakani performed well at the semi-arid site. Accessions 219, 152,137, 232 and 9051 were productive at both the semi-humid and the semi-arid sites. This good adaptability is in agreement with Whiteman (1980) who stated that *C. pubescens* is adapted to tropical coastal situations. Its DM yields from the initial cut at three months were low, but yields increased for the nine- and 12-month cuts. *C. pubescens* is slow to establish and requires thoroughly prepared seed-beds, but once established it becomes vigorous and produces good quality forage (Whiteman 1980). Experiments carried out at Mariakani (Njunie and Ogora 1991) showed that *C. pubescens* mixed well with *Chloris gayana.* Humphreys (1978) reported that C. *pubescens* has the ability to form mixtures with tufted grasses including *Brachiaria sp* and that when established it is moderately palatable and can withstand heavy grazing.

Generally, *Desmodium adsendens, D. canum, D. sandwicense, D. uncinatum* and *D. intortum* performed poorly and therefore do not warrant further testing in the coastal lowlands. Amongst the less persistent species and accessions, *Lablab purpureus* produced the highest dry matter yields during the early initial harvests at three and six months following planting, but did not persist under frequent harvesting. This is in agreement with its growth habit as reported by Skerman et al (1988). *Lablab* is widely planted as a green manure crop (Cameroon 1988). At Lamu in coastal semi-humid Kenya, its suitability as a green manure crop was evaluated in food production systems. Maize grain yields following *Lablab* cropping were twice as high as after maize or cotton (GASP 1990). Humphreys (1978) found that *Lablab* performed effectively as standover grazing in conjunction with poor quality cereal residue, making a significant contribution to improved seasonal feed availability.

High DM yields were also recorded for the early harvests of *Macrotyloma axillare* and *Calopogonium mucunoides.* Performances were consistent with the findings of Skerman et al (1988). These legumes can provide large quantities of forage within a short period, and also suppress weed growth. *Calopogonium mucunoides* is also suitable as a cover crop and complements *Centrosema pubescens* because the latter is slow to establish (Reynolds 1988). *Lablab purpureus, Macrotyloma axillare* and *Calopogonium mucunoides* are suitable as cover crops in short-term (one-season) fallows and can serve as valuable feed resource for early grazing and/or contribute to early season forage production in cut-and-carry feeding systems.

Macroptilium atropurpureum (392) and *Centrosema pubescens* (9051) gave low DM in the initial cut, yet produced high DM in latter cuts and should be evaluated as intercrops with food crops. They can fix large amounts of nitrogen annually in food production systems (over 75 kgN/ha, Haque et al 1986). *Clitoria ternatea (9282), Lablab purpureus (11609)* and *Macrotyloma axillare (756)* have potential to improve soil fertility through leaf fall. Though this trait is undesirable for farmers growing forage for feeding livestock, these legumes improve soil fertility by providing legume leaf mulch *in situ* and hence improving soil organic matter content making them suitable for integration into food crop systems (Haque et al *1986). Macroptilium atropurpureum* and *Centrosema pubescens* can also grow well under shade of coconut trees (Reynolds *1988).*

In conclusion, the range of growth habits found among the 62 accessions extends from vigorous growth during the establishment period making them suitable for short term cover-cropping, fodder bulking and green manure crops, through to the persistent types with frequent harvesting which are good traits for cut-and-carry systems. This germplasm therefore represents a wide range of options for improving smallholder farm productivity through the introduction of herbaceous legumes. The promising material requires agronomic experimentation and on-farm testing to promote the adoption of the technologies to increase forage supplies and improve soil fertility.

References

Cameroon D.G. 1988. Lablab bean *(Lablab purpureus).* The major leguminous forage crop. *Queensland Agricultural Journal* 114:10–113*.*

FAO (Food and Agriculture Organization of the United Nations). 1981. Collection and evaluation of plants for animal production in Kenya. Terminal report — AG GCP/ KEN/NOR.

Haque I., Jutzi S. and Neate P.J.H. (eds). 1986. *Potential of Forage Legumes in Farming System of Sub-Saharan Africa.* Proceedings of a workshop held at Addis Ababa, Ethiopia, 16–19 September, 1985. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Humphreys L.R. 1978. *Tropical pastures and fodder crops.* Intermediate Tropical Agriculture Series. Reprinted 1980 and 1984. Longman Group Limited.

Jaetzold R. and Schmidt H. 1983. *Farm Management Hand Book of Kenya. Volume IIc. East Kenya (Eastern and Coast provinces).* Farm Management Branch, Ministry of Agriculture, Nairobi, Kenya. 411 p.

Jama B. 1988. *A Study of Alley Cropping Maize and Green Grams with* Leucaena leucocephala *(Lam, de Wit) at Mtwapa, Coast Province of Kenya.* MSc thesis, University of Nairobi, Nairobi, Kenya.

Jama B., Getahun A. and Ngugi D.N.1991. Shading effects of alley cropped *Leucaena leucocephala* on weed biomass and maize yield at Mtwapa, Coast Province, Kenya. *Agroforestry Systems*13:1–11.

GASP (German Assisted Settlement Programme). 1990. Report on results of agricultural trials. Lake Kenyatta and Hindi Settlement Schemes. 46 pp.

Mureithi J.G. 1992. *Alley Cropping with* Leucaena *for Food and Fodder Production in Smallholder Farms in Lowland Coastal Kenya.* PhD thesis, Department of Agriculture, University of Reading, Reading, UK.

Mureithi J.G. and Thorpe W. 1993. *The effects of herbaceous legume intercropping and mulching on productivity of Napier grass and total forage yield in coastal lowland Kenya.* AFRNET workshop, Harare, Zimbabwe, December 1993 (in press).

Njunie M.N. and Ogora R.B. 1991. Evaluation of forages of the semi-arid coastal lowland zone. In: *Recent Advances in KARI's Research Programmes. Proceedings of the 2nd KARI Scientific Conference held at Panafric Hotel, Nairobi, Kenya, 5–7 September 1990.* KARI (Kenya Agricultural Research Institute), Nairobi, Kenya. pp. 116–123.

Reynolds S.G. 1988. *Pastures and Cattle under Coconuts.* FAO Plant Production and Protection Paper 91. Food and Agricultural Organization of the United Nations, Rome, Italy.

Siderius W. and Muchena F.N. 1977. *Soils and Environmental Conditions of Agricultural Research Stations in Kenya.* Kenya soil survey reports. Miscellaneous Soil Paper M5. National Agricultural Laboratories, Kenya.

Skerman P.J., Cameron D.G. and Riveros F. 1988. *Tropical Forage Legumes.* FAO Plant Production and Protection Series 2. Rome, Italy.

Thorpe W., Maloo S.H., Muinga R.W., Mullins G., Mureithi J.G., Njunie M., Ramadhan A. and Reynolds L. 1993. Research on smallholder dairy production in coastal lowland Kenya: a collaborative programme between Kenya Agricultural Research Institute and International Livestock Centre for Africa. In: *Proceedings of the Workshop on The Future of Livestock Industries in East and Southern Africa held in Kodoma, Zimbabwe, 20–22 July 1992.* ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 33–44

Whiteman P.C. 1980. *Tropical Pasture Science.* Oxford University Press UK.

Evaluation de légumineuses fourragères herbacées dans la plaine côtiére de l'Afrique de de l'Est

Résumé

Des ressources génétiques de légumineuses herbacées comprenant 62 acquisitions appartenant à 18 espèces ont été choisies pour leur potentiel d'adaptation aux plaines côtières tropicales et évaluées dans trois zones agro-ecologiques du littoral kenyan. Trois de ces 62 acquisitions étaient des génotypes locaux connus pour leur productivité, alors que les 59 autres lots provenaient de la banque de gènes du CIPEA. Les trois zones agro-écologiques choisies

sont la zone semi-humide de culture du coco et du manioc (pluviométrie annuelle "élvée" comprise entre 1050 et 1230 mm), la zone de culture de l'anacardier et du manioc (zone de transition à pluviométrie "moyenne" située entre 920 et 1000 mm) et la zone d'élevage et de culture du millet (zone semi-aride à "faible" pluviométrie allant de 800 à 900 mm), toutes des zones à pluviométrie bimodale. Les sols des sites d'essai sont sableux et pauvres en matière organique et en éléments nutritifs des plantes. L'effet de coupes à 3, 6, 9 et 12 mois après le semis a été étudié sur la productivité et la viabilité des légumineuses herbacées, de même que la productivité en fonction du nombre de coupes (une, deux, trois ou quatre) sur une période de 12 mois après le semis.

Le taux de germination était généralement satisfaisant (plus de 60%) sur tous les sites. Dans la zone semi-humide, la production de mature sèche (MS) augmentait au fur et à mesure qu' on retardait la première coupe. Cette évolution était en revanche moms prononcée pour la zone semi-aride. Les rendements en MS de la zone semi-humide étaient en moyenne de 0,24; 0,54; 0,56 et 0,71 kg/m de rangée pour les coupes effectuées respectivement 3, 6, 9 et 12 mois aprs le semis. Les espèces les plus résistantes des zones semi-humide et semi-aride étaient *Macroptilium atropurpureum, Clitoria ternatea, Centrosema pubescens, Neonotonia wightii* et *Macroptiliu lathyroides.* Quant à *Pueraria phaseoloides, Galactia striata* et *Centrosema arenarium,* elles ont bien résisté aux coupes fréquentes dans la zone semi-humide, mais seine Centrosema virginianum y avait résisté duns la zone semi-aride.

Dans l'ensemble, les parcelles soumises à quatre coupes par an ont fourni les rendements cumulatifs les plus élevés de MS. Sur le site à "forte" pluviométrie, les rendements moyens des 12 sélections les plus résistantes et les plus productives étaient de 1,34;125 ;1,10 et 0,71 kg de MS/m de rangée pour quatre, trois, deux et une coupe(s) respectivement. Sur le site semi-aride, le rendement cumulatif de MS était en moyenne de 60% inférieur à celui du site à "forte" pluviométrie et les rendements de la saison sèche ètaient de 25% inférieurs à ceux des autres saisons en raison de l'importante chute des feuilles. Sur le site a pluviométrie "moyenne", l'implantation de la plupart des légumineuses était médiocre car elles avaient été semées vers la fin de la saison des pluies. En ce qui concerne la couverture des parcelles et la viabilité des plants, 5 acquisitions de *Clitoria ternatea* figuraient parmi les 7 légumineuses les plus performantes.

On peut conclure que *Macroptilium atropurpureum* et *Clitoria ternatea* font partie des légumineuses herbacées les plus productives pour la zone côtiède d'Afrique de l'Est. Les bonnes performances de*Lablab purpureus*, *Macrotyloma axillare* et *Calopogonium mucunoides* au cours des premières coupes montrent que ces espèces doivent faire l'objet d'évaluations plus poussées dans le cadre d'essais agronomiques en cultures intercalaires ou dérobées. Par ailleurs, leur valeur nutritive en tant qu'aliment du bétail et leur effet sur les performances des animaux doivent également être étudiés.

Initial evaluation of some introduced forage plants for herbage production at two sites in Ghana

P.B. Barnes and A. Addo-Kwafo

Animal Research Institute, Achimota, Ghana

Abstract

A preliminary evaluation of the forage germplasm obtained from CIAT (comprising 21 herbaceous legumes, 6 shrubby legumes and 8 grasses) and from ILCA in Ethiopia (20 forage legumes) was undertaken at two sites in Ghana with average annual rainfalls between 1000 and 1200 mm.

Of the herbaceous legumes from CIAT grown at only one of the two sites, *Aeschynomene histrix, Centrosema macrocarpum* var 5452 and 5713, *Desmodium ovalifolium* and *Stylosanthes guianensis cv* Pucallpa and var *pauciflora* produced the highest soil cover (28 to 58%) and dry matter yields (up to 2.25 t/ha in 6 months after planting), whereas *Arachis pintoi, Desmodium strigillosum* and *Zornia glabra* performed poorly. *Brachiaria brizantha* and *Panicum maximum* accessions and *Brachiaria decumbens* cv Basilisk performed best among the grasses (up to 3.7 t/ha in 6 months). Among the leguminous shrubs *Leucaena leucocephala* and *Cajanus cajan* grew tallest and produced the highest dry matter yields.

Among the 20 legumes from ILCA, *Macrotyloma axillare, Stylosanthes guianensis* ILCA 4, *Stylosanthes hamata* ILCA 167, *Lablab purpureus, Rhynchosia minima* and *Stylosanthes scabra* ILCA 140 and 441 showed high herbage yields (up to 3.8 tons/ha in six months) at both sites.

Introduction

Forage species evaluation studies conducted over three decades by various agricultural institutions and universities in Ghana have resulted in the release of introduced forage legumes species like*Stylosanthes guianensis, Centrosema pubescens, Pueraria phaseoloides, Mucuna pruriens* and grasses like *Cenchrus ciliaris* and *Digitaria decumbens.*

Forage evaluation studies with germplasm received from CSIRO (Australia) conducted in Pokoase, Ghana (lat. 5°40' N, annual rainfall 1050 mm) showed that forage legumes like *Stylosanthes guianensis (cvs* Cook, Graham and Endeavour), *Stylosanthes scabra* (Fitzroy and Seca), *Stylosanthes hamata* (Verano), *Stylosanthes humilis* (cordon) and grasses such as *Cenchrus ciliaris* (cvs Biloela and Gayndah), *Digitaria pentzii, Urochloa* spp and *Panicum maximum* cultivars established well and have been productive for several seasons (Barnes 1985). This initial evaluation study attempted to assemble a broader array of forage types suitable for zero-grazing, green manure, fodder banks and permanent pastures.

Materials and methods

Trial 1. Evaluation of Centro International de Agricultura Tropical (CIAT) Forage Materials

The trial was conducted at Pokoase Agricultural Station (lat. 5°40'N), which lies in the transition between forest and coastal savannah zones. The soil of the site is derived from alluvial deposits and is of medium fertility. Annual rainfall averaged 1050 mm but varied from 1216 mm in 1991 to 632 mm in 1992 (Table 1). Normally, the main rainfall period extends from April to November with a short dry spell in August.

Table 1. *Monthly rainfall totals (mm) and rainy days for two years (1991–1992) for Pokoase and Nyankpala* agricultural *stations.*

	Pokoase				Nyankpala			
	1991		1992		1991		1992	
	mm	(days)	mm	(days)	mm	(days)	Mm	(days)
January	31	(2)	–	–	–	–	–	
February	4	(1)	–	–	48	(2)	–	(1)
March	21	(3)	33	(3)	30	(2)	13	(5)
April	110	(7)	31	(4)	91	(6)	69	(6)
May	501	(14)	123	(4)	257	(3)	45	(9)
June	155	(10)	31	(5)	98	(7)	97	(9)
July	252	(9)	30	(8)	180	(11)	127	(5)
August	38	(7)	7	(3)	364	(13)	745	(11)
September	23	(5)	183	(7)	255	(13)	234	(4)
October	50	(5)	67	(10)	103	(9)	31	(4)
November	28	(6)	129	(7)	–	–	46	
December	15	(2)	–	–	–	–	–	

The experimental design was randomised complete blocks with three replications. In all, 35 forage entries made up of 21 herbaceous legumes, six shrubby legumes and eight grasses (Table 2). Gross plot size was 5 m × 2.5 m and sample areas within plots measured 4.0 m^2 (4 m × 1 m) involving two central rows of plants. Sowing of the herbaceous legumes and grasses was done in 4 rows per plot at a spacing of 50 cm and seed was drilled in a continuous flow in the rows. Seeds of shrub species were planted 50 cm apart in 4 rows. Sowing of all plots was carried out on 22nd August 1991 on cultivated seed-beds.

Table 2. *Soil cover % of herbaceous legumes and grasses at 12 weeks after sowing and dry matter yield (t/ha) of all entries after six months growth.*

Species/accessions (herbaceous legumes)	CIAT no. or Variety	% soil cover at 12 wks	dry matter yield (t/ha) at 6 months
Aeschynomene histrix	9690	53	2.25
Arachis pintoi	17434	11	0.33
Cassia rotundifolia	Wynn	31	1.00

Centrosema acutifolium	Vichada	38	0.75
C. acutifolium	5568	46	0.33
C. brasilianum	52234	60	1.25
C. macrocarpum	5452	56	1.67
C. macrocarpum	5713	58	1.53
C. pascuorum	Cavalcade	40	1.42
C.pubescens	5172	41	0.83
Desmodium ovalifolium	13089	18	1.67
D.strigillosum	13155	2	–
Stylosanthes capitata	Capica	28	0.38
S. guianensis	Pucallpa	48	2.03
S. guianensis	Pauciflora	28	1.92
S. hamata	Verano	33	0.42
S. hamata	147	67	1.00
S macrocephala	1281	15	0.32
S. sympodialis	1044	48	0.83
Zornia glabra	8279	43	0.92
Z. latifolia	728	12	–
	SE (mean)	(±5)	(±0.21)
GRASSES			
	Carimagua	16	0.43
Andropogon gayanus	La Libertad	31	3.67
B. brizantha	Marandu	18	0.83
B. brizantha	Basilisk	46	2.67
B. dictyoneura	Llanero	12	0.50
B. humidicola	6379	21	0.83
Panicum maximum	673	46	1.42
P. maximum	T58	44	2.00
	SE (mean)	(± 6)	(±0.05)

Recordings

Establishment assessment was done at 8 (22.10.91) and 12 weeks (5.12.91) after sowing using a 1 m^2 quadrat subdivided into 25 squares, 0.2 × 0.2 m in size. Soil cover percentage was estimated in each square and averaged to give total cover. For the shrubs, plant height was recorded at 8 and 12 weeks as a measurement of establishment performance. Primary assessments of all 35 entries were assessed six months after establishment in the middle of the dry season (on 24.2.92). Herbage was harvested at 5–10 cm above ground for prostrate species, at 10–15 cm for erect species and at 20–30 cm for shrubs; fresh weight was recorded in the field. The samples were sun-dried for four days and then weighted.

Trial 2. Evaluation of forage materials from the International Livestock Centre for Africa (ILCA)

This evaluation was conducted at two sites, namely, Pokoase as described for the CIAT trial and Nyankpala (lat 9°40'N) which lies in the guinea savanna zone and has mean annual rainfall of 1081 mm. The soil in the trial area is a well-drained loam. The forage legumes (Table 3) were sown in a randomised complete block design with 4 blocks of 20 plots (legumes) per block. The plot size was 1 m × 3 m and plots were separated by lm wide and blocks by 2 m wide strips. Seed was sown in two, 3 m length rows spaced 40 cm apart in the middle of each plot. The trials were sown on 1.6.92 in Pokoase and the Nyankpala trial on 17.7.1992. Herbage was harvested 6.5 months later in Pokoase on 16.12.92 and at Nyankpala on 10.12.92, when maximum growth in most entries was reached. The harvests were taken from the middle lm^2 of each plot at between 5–10 cm height above ground. Dry weights were determined after oven-drying for 48 hrs at 60°C.

Table 3. *Plant height of shrubs at 12 weeks after sowing and dry matter yield (t DMlha) after six months primary growth.*

Legume/Shrub	CIAT no. or Variety	Plant height	Yield t DM/ha (cm)
Cajanus cajan	18700	103	0.70
Cratylia argentea	18516	33	0.42
Codariocalyx gyroides	3001	21	0.30
Desmodium velutinum	33138	–	–
Flemingia macrophylla	17403	19	0.22
Leucaena leucocephala	17502	55	0.50
	SE (mean)	(± 2.2)	(± 0.11)

Results

Trial 1

The trial was sown in August 1991 and preliminary observations made in February 1992. Most rain had fallen before planting and only 140 mm fell after late August up to harvest which may explain low yields (Table 1). Soil cover percentage for grasses and herbaceous legumes and plant height of shrubs and dry-matter yields of herbage of all entries are shown in Tables 2. The accessions with high cover were *Stylosanthes hamata* 147, *Centrosema brasilianum, C. macrocarpum* 5713 and 5452 and *Aeschyomene histrix.* Entries with low soil cover were *Desmodium strigillosum, Arachis pintoi, Zornia latifolia, Stylosanthes macrocephala* and *Desmodium ovalifolium.*

Aeschynomene histrix, Stylosanthes guianensis cv Pucallpa and var *pauciflora* and *Centrosema macrocarpum* 5452 and 5713 and *Desmodium ovalifolium* produced between 1.5 and 2.2 t DM/ha. Corresponding to their low soil cover percentages there were low dry-matter yields in *Arachis pintoi* and several *Stylosanthes* sp, while *Zornia latifolia* and *Desmodium strigillosum* failed almost completely. There was no positive correlation between soil cover and dry matter yields in *Desmodium ovalifolium* and *Stylosanthes hamata* 147.

Soil cover of grasses was highest in *Brachiaria decumbens* cv Basilisk and the *Panicum maximum* cultivars, corresponding to DM yields of 1.4 to 2.7 t DM/ ha. By contrast, *Brachiaria brizantha* cv La Libertad yielded 3.7 t DM/ ha with a soil cover percentage of 31.4% (Table 2). Among leguminous shrubs, *Cajanus cajan* reached a height of 0.7 m followed by *Leucaena leucocephala* with 0.5 m. There were positive relationships between plant height and dry matter yield in all entries (Table 3).

Trial 2

In Pokoase, total rainfall after planting amounted only 445 mm and included a dry spell up to September (Table 1). In Nyankpala, over 800 mm fell, mostly from July to late September. Despite this difference, there were higher herbage yields for most entries at Pokoase than at Nyankpala probably because 1.5 months longer growth period and 380 mm of rain during Sep.–Nov. in the former site (Table 1).

At Pokoase the highest dry matter yielding entries were *Macrotyloma axillare, Stylosanthes hamata* 167 and 75, *Rhynchosia minima, Lablab purpureus, Stylosanthes guianensis* 4, and *Stylosanthes scabra 140* and *441.* Thirteen out of 20 accessions produced more than 2 t DM/ha. However, *Centrosema brasilianum, Centrosema pascuorum* and *Chaemacrista rotundifolia* failed to establish well for no known cause.

At Nyankpala, the highest yielding entries were *Stylosanthes scabra, Centrosema brasilianum, Macrotyloma axillare* and *Lablab purpureus.* Only three entries produced dry matter yields >2t DM/ha and another 10 yielded between dry matter yields l and 2 t of DM. At both sites *Zornia latifolia, Chaemacrista rotundifolia* and *Desmodium uncinatum* established poorly or showed very low herbage yields. Otherwise the rest of the entries established and adapted well to the conditions at both sites.

Table 4. *dry matter yields after six months primary growth of forage legume entries used in trial 2 at two sites, Pokoase and Nyankpala in Ghana.*

Entry (Species/Accession)	ILCA no.	Yield (t DM/ha)	
		Pokoase	Nyankpala
Centrosema brasilianum	6773	–	2.30
C. pascuorum	6774	–	1.60
C. pubescens	219	2.41	1.75
Chamaecrista rotundifolia	9288	–	–
Clitoria ternatea	9291	2.33	1.43
Desmodium intortum	104	2.12	0.45
D. uncinatum	6765	0.82	0.45
Lablab purpureus	147	2.89	1.98
Macroptilium atropurpureum	69	2.26	1.88
Macrotyloma axilare	6756	3:29	2.08
Neonotonia wightii	6761	2.21	0.18
Rhynchosia minima	13935	2.94	1.45

Stylosanthes guianensis	4	2.87	1.33
S guianensis	163	1.94	1.37
S. hamata	75	2.73	1.50
S. scabra	167	3.07	1.33
Vigna unguiculata	140	2.79	–
Zornia latifolia	441	2.64	3.40
	9333	–	–
	172	–	0.57
	SE (mean)	(±0.55)	(±0.33)

Discussion

The forage materials evaluated in trial one were developed by the Tropical Pastures Program, CIAT, Colombia. This trial established that among the herbaceous legumes, *Aeschynomene histrix, Centrosema macropcarpum, Desmodium ovalifolium* and *Stylosanthes guianensis* produced the highest rates of primary growth.

In a study involving effect of cutting intervals on herbage yields of some legumes in the coastal savanna of Ghana, Adjei and Fianu (1985) found that *Aeschynomene americana* and *Cajanus cajan*produced the highest dry matter yield among the legumes evaluated which included *Stylosanthes humilis, Macroptilium lathyroides, M. atropurpureum, Centrosema pubescens* and *Desmodium intortum.*

Forage materials evaluated for the first time by the Animal Research Institute of Ghana and which showed high promise for forage production were *Centrosema macrocarpum, Desmodium ovalifolium, Lablab purpureus* and *Macrotyloma axillare.* These forage materials may be suitable for zero-grazing and short-term sown pastures.

In the evaluation *of Centrosema* spp. in Puerto Rico, Central America, Ramos and Tergas (1990) found that *Centrosema brasilianum, Centrosema pubescens* and *Centrosema macrocarpum*accessions produced the best average soil cover of up to 84% after 16 weeks up from 35% at 12 weeks after establishment. This finding corroborates the observations in the current study.

Arachis pintoi is a much acclaimed forage species in humid tropics. In the current study it showed poor establishment, spread and dry matter production. This may be attributed to the low rainfall in the present study site. In Australia it provides ground cover in orchards and it is valued as a pasture legume being persistent under heavy grazing and growing well in shaded places.

Among the grasses, *Brachiaria brizantha* (La Libertad), *Brachiaria decumbens* cv Basilisk and *Panicum maximum* varieties showed the highest dry-matter yields. Heering (1989) evaluated a number of *Brachiaria* species at Zwai (Ethiopia) for features like leafiness, ground cover, vigour, spread and plant height. He found that accessions of *B. decumbens, B. ruziziensis* and *B. brizantha* showed the best performance. This finding confirms the results of the present study.

Establishment and primary growth of the forage shrubs *Leucaena leucocephala, Gliricidia sepium* and *Cajanus cajan* have been successful in many areas in West Africa (Cobbina et al 1990; Adjei and Fianu 1985). Primary growth of seven tons/ha and five tons/ha have been obtained in stands of *Leucaena* and *Gliricidia* after 12 months. The current study confirmed that *Leucaena* and *Cajanus cajan*established well.

Forage shrubs evaluated for the first time by the Animal Research Institute of Ghana and which seem to have high potential in foliage production are *Cratylia argentea* and *Codariocalyx gyroides.* In a dry matter yield study of some native legumes and *Codariocalyx gyroides* in Belize, Lazier (1981) found that C. *gyroides* was successful among entries from the genera *Centrosema, Desmodium, Calopogonium* and species like *Macroptilium lathyroides, Rhynchosia minima* and *S guianensis.*

Further studies will be carried out on all entries that showed promise in this initial evaluation study.

References

Adjei M.B. and Fianu F.K. 1985. The effect of cutting interval on the yield and nutritive value of some tropical legumes on the coastal grassland of Ghana. *Tropical Grasslands* 19(4):164–170.

Barnes P.B. 1985. Preliminary evaluation of some introduced pasture species for dry matter yields in a sub-humid environment in Ghana. *PGRC/E–ILCA Germplasm Newsletter* 9:3–8.

Cobbina J., Attah-Krah A.N. Meregini, A.O. and Duguma B. 1990. Productivity of some browse plants on acid soils of southeastern Nigeria. *Tropical Grassland* 24:41–45.

Heering J.H. 1989. Initial evaluation of Brachiaria species. *PGRC/E–ILCA Germplasm Newsletter* 20:2–6

Lazier J.R. 1981. Dry matter productivity of eighteen native Belizean legumes and Codariocalyx gyroides with Para grass (Brachiaria mutica) under clipping. Tropical Agriculture (Trinidad) 58(3):221–233.

Santana R. and Tergas L.E. 1990. The establishment and adaptation of forage crops on Ultisol in Puerto Rico. 2. Centrosema spp. *Pasturas Tropicales (Colombia)* 12 (1):30–34.

Evaluation préliminaire de la production de quelques plantes fourragères introduites sur deux sites au Ghana

Résumé

Une évaluation préliminaire de ressources génétiques fourragères provenant du CIAT (21 légumineuses herbacées, 6 légumineuses arbustives et 8 graminées) et du CIPEA en Ethiopie (20 légumineuses fouragères) a été effectuée sur deux sites du Ghana où la pluviométrie annuelle varie entre 1000 et 1200 mm.

Parmi les légumineuses herbacées du CIAT cultivées seulement sur l'un des deux sites, *Aeschynomene histrix, Centrosema macrocarpum* var. 5452 et 5713, *Desmodium ovalifolium* et *Stylosanthes guianensis* cv. Pucallpa et var. *pauciflora* ont donné la meilleure couverture des sots (28 à 58%) et les meilleurs rendements en matière sèche (jusqu'à 2,25 t de MS/ha en six mois), tandis qu'*Arachispintoi, Desmodium strigillosum* et Zornia glabra ont eu des performances médiocres. Chez les graminées, les acquisitions de *Brachiaria brizantha, Panicum maximum* et *Brachiaria decumbens* cv. Basilisk ont donné les meilleurs résultats (jusqu' à 3,7 t/ha en six mois). S'agissant des légumineuses arbustives, *Leucaena leucocephala* et *Cajanus cajan* ont le mieux poussé, avec les meilleurs rendements en matière sèche.

Parmi les 20 lègumineuses du CIPEA, *Macrotyloma axillare, Stylosanthes guianensis* ILCA 4, *Stylosanthes hamata* ILCA 167, *Lablab purpureus, Rhynchosia minima* et *Stylosanthes scabra* ILCA 140 et 441 ont donnè les meilleurs rendements en matière sèche (jusqu'à 3,8 t de MS/ha en six mois) sur les deux sites.

Seasonal dry matter productivity of introduced forage plants in a subhumid site in Ghana

P.B. Barnes

Animal Research Institute, Achimota, Ghana

Abstract

Twenty-one herbaceous legumes, six leguminous shrubs and eight grasses obtained from CIAT, Colombia, South America were further evaluated for dry matter yield in the second year (1992/93) after having earlier been screened for ease of establishment and initial growth at Pokoase, a subhumid site in Ghana. Among the herbaceous legumes outstanding entries for herbage yield during two seasons were *Centrosema macrocarpum* CIAT 5452 and 5713; *Centrosema acutifolium* cv Vichada and CIAT 5568, and *Stylosanthes guianensis* cv Pucallpa and var *pauciflora*. Of the grasses,*Brachiaria brizantha* cvs la Libertad and Marandu and *Panicum maximum* CIAT 673 and T58 were the best entries. *Cajanus cajan CIAT* 18700 was the best herbage yielder among the woody species that included *Cratylia argentea, Codariocalyx gyroides, Flemingia macrophylla* and *Leucaena leucocephala.*

Introduction

A series of forage germplasm material has been evaluated for establishment characteristics and primary growth and was subjected to further evaluation of herbage productivity during subsequent seasons. The accessions were obtained from CIAT (Centro International de Agricultura Tropical), Colombia and consisted of 21 herbaceous legumes, six shrub legumes and eight grasses.

Earlier screening of forage accessions received from Australia (CSIRO Tropical Crops and Pastures Division) over the years had shown that the following herbaceous legume species are suitable for the main agroclimatic zones in Ghana: *Stylosanthes guianensis, Centrosema pubescens, Macroptilium atropurpureum* while the most suitable shrub legumes are *Leucaena leucocephala, Gliricidia sepium* and *Flemingia macrophylla.* The best grasses are *Cenchrus ciliaris* (Buffel grass) and *Digitaria decumbens* (Pangola grass).

The objective of this study was to identify other promising forages from material evaluated in South America and quantify their productivity and suitability for different forage utilisation systems in Ghana.

Materials and methods

The trial site was located at Pokoase, an agricultural station which lies in the coastal forest savanna transitional zone. Pokoase is located on latitude 5°40'N and longitude 0°20' W, at an altitude of 152 m asl. The soils of the site form part of the forest Ochrosol series and are largely derived from alluvial deposits.

During the first year of evaluation, the rainfall was monomodal, over 900 mm falling from May through July and only 140 mm falling thereafter. In the second year the distribution was entirely different with some rain in April, followed by four relatively dry months. More than half of the total fell during September–November and small amounts were recorded later in the dry season (Table 1).

Table 1. *Monthly rainfall totals (mm) and rainy days for 1991, 1992 and part of 1993.*

	1991		1992		1993	
Month	mm	Days	mm	days	mm	days
January	31	2	0		8	1
February	4	1	0		40	3
March	21	3	33	3	39	5
April	110	14	123	4	4	4
May	501	14	31	5		
June	155	10	31	5		
July	252	9	29	8		
August	38	7	7	3		
September	23	5	183	7		
October	50	5	67	10		
November	28	5	129	7		
December	5	2	0			
Total	1216		633			

Results

The dry matter herbage yield for the herbaceous legume entries at the different regrowth periods in the wet and dry seasons are shown in Table 2. The highest yielding entry in the first two regrowth periods of three and six weeks was *Desmodium ovalifolium,* followed closely by *Centrosema macrocarpum CIAT* 5452 and *CIAT* 5713. However, the two *C. macrocarpum* varieties yielded highest consistently for nine weeks regrowth in the wet season and 12 weeks regrowth in the dry season.

Table 2. *Dry matter herbage yield (kg DM/ha) of herbaceous legume entries at different regrowth periods in the wet and dry seasons (1992/93) and total yield (t DM/ha*).

	Wet season				Dry season		Total[1]
Accessions	3 wk	6 wk	9 wk	12 wk	6 wk	12 wk	t DM/ha
Aeschynomene histrix (9690)	117	402	771	1354	485	810	2.2
Arachis pintoi (17434)	133	207	573	577	553	1163	1.7
Cassia rotundifolia (Wynn)	103	274	761	790	1105	1145	1.9
Centrosema acutifolium (Vichada)	207	570	869	1309	1230	1413	2.7
C. ocutifolium (5568)	207	495	851	1221	1180	1600	2.8
C. brasilianum (5234)	260	581	908	1141	1227	1540	2.7

C. macrocarpum (5452)	183	683	1159	1420	1630	2830	3.1
C. macrocarpum (5713)	267	607	1405	1878	2100	2353	4.2
C. pascuorum (Cavalcade)	220	377	931	1185	625	–	–
C.pubescens (5172)	310	341	815	1675	2010	2350	4.0
Desmodium ovalifolium (13089)	525	789	1110	1398	1355	1050	2.4
Stylosanthes capitata (Capica)	277	369	1122	1661	755	1950	3.6
S. guianensis (Iucallpa)	243	529	1315	2009	610	1653	3.7
S. guianensis (pauciflora)	273	592	1185	1985	2023	3317	5.3
S. hamata (Verano)	240	276	735	1301	1117	1540	2.8
S. macrocephala (1281)	205	412	680	920	–	–	–
S. sympodialis (1044)	127	291	670	1193	997	917	2.1
Zornia glabrata(8279)	147	183	8655	903	1187	138	1.0
Z. latifolia (728)	370	378	8771	1041	970	930	2.0
SE (±)	67	78	90	237	197	191	

1 Total of 12 weeks growth in the rainy and dry season.

Other entries with consistent high herbage yields were *Aeschynomene histrix, Centrosema acutifolium* and *Stylosanthes guianensis* accessions.

Aeschynomene histrix however showed poor yields in the dry season. Zornia latifolia like *Desmodium ovalifolium* showed high yields in the first two regrowth periods but decreased in yields thereafter.*Arachis pintoi, Cassia rotundifolia* and *Zornia glabra* produced low dry matter yields in the wet season but yielded better in the dry season. For most of the entries, regrowth yields in the dry season was higher than in the wet season. The best performers in the dry season were the two *Centrosema macrocarpum* varieties, *Stylosanthes guianensis* var pauciflora and *Centrosema pubescens.*

For the grasses, dry matter herbage yields increased as regrowth period lengthened and generally the dry season yields for the two regrowth periods were higher than the same periods in the wet season (Table 3). The two *Brachiaria brizantha* varieties were the best overall yielders in both seasons. The two varieties of *Panicum maximum* and then *Brachiaria decumbens cv* Basilisk were the next best, whereas *P. maximum* T58 outyielded all in the dry season.

Table 3. *DM yields (kg/ha) of grasses at 3, 6, 9 and 12 weeks after cutting in the wet season, at 6 and 12 weeks after cutting in the dry season and total yield (t DM/ha) in 1992/93.*

	Wet season				Dry season		Total[1]
Entries	3 wk	6 wk	9 wk	12 wk	6 wk	12 wk	t DM/ha
Andropogon gayanus (Carimagua)	228	676	762	953	2523	1880	2.8
Brachiaria brizantha (La Libertad)	573	903	1922	3524	2177	3727	7.3
B. brizantha (Marandu)	440	669	1255	3086	2120	4130	7.2
B. decumens (Basilisk)	373	632	1261	1725	1230	3187	4.9

B. dictyoneura (Llanero)	370	500	1622	2468	1985	2375	4.8
B. humidicola (6379)	260	430	855	1672	1810	2320	4.0
Panicum maximum (673)	573	864	865	2301	1693	2650	5.0
P. maximum (T58)	763	1748	2320	2745	4504	8293	11.0

1 Total of 12 weeks growth in the wet and dry season.

Of the legume shrub entries the most outstanding entry in herbage yield was *Cajanus cajan* followed by *Leucaeana leucocephala* in the wet season.

The other three entries, *Cratylia argentea, Codariocalyx gyroides* and *Flemingia macrophylla* produced similar herbage yields in both seasons.

Leucaena leucocephala was poor while *Desmodium velutinum* was one of the shrub entries which established poorly (Table 4).

Table 4. *DM yields (kg/ha) of shrub legumes at 3, 6, 9 and 12 weeks after cutting in the wet season and at 6 and 12 weeks after cutting in the dry season of 1992/93.*

	Wet season				Dry season		Total
Entries	3 wk	6 wk	9 wk	12 wk	6 wk	12 wk	t DM/ha
Cajanus cajan (187008)	287	855	2031	3938	3350	6907	10.8
Gratylia argentea (185168)	167	852	1261	1880	2047	4897	6.9
Codariocalyx gyroides (3001)	230	661	996	1550	2400	3017	6.9
Flemingia macrophylla (17403)	303	490	1237	1830	1837	2927	5.4
Leucaena leucocephala (17502)	393	765	1866	2302	1713	2000	4.7
SE (±)	67.6	188.2	359.6	306.6	500.0	705.2	3.7

Discussion

In general, dry matter yields increased as regrowth period lengthened and it was noteworthy that dry matter yields in the dry season were higher than in the wet season. This may have been caused by the high rainfall from September to November 1992 (Table 1).

The outstanding herbage yields of accessions of *Centrosema macrocarpum, C. acutifolium, C. pubescen* and *Stylosanthes guianensis* show promise justifying further evaluation in terms of persistence, animal production and fodder bank establishment. In a study on the effect of cutting intervals on herbage yields of some legumes in the coastal savanna of Ghana, Adjei and Fianu (1985) found that *Aeschynomene americana* and *Cajanus cajan* produced the highest dry matter yields and performed better than *Stylosanthes humilis, Macroptilium lathyroides, M. atropurpureum, Centrosema pubescens* and *Desmodium intortum.*

The high yields of *Brachiaria brizantha* and *B. decumbens* agree with Heering (1989) who found that among a number of *Brachiaria* species evaluated in Zwai, Ethiopia, accessions of *B. decumbens, B. ruziziensis* and *B. brizantha* performed best. *Cajanus cajan* and *Leucaena leucocephala* were the most outstanding forage shrubs. Three other entries *(Cratylia argentea,* *Codariocalyx gyroides*and *Flemingia macrophylla)* which had similar productivity in both the wet and dry seasons merit further evaluation (Lazier 1981).

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References

Adjei M. B. and Fianu F.K.1985. The effect of cutting interval on the yield and nutritive value of some tropical legumes on the coastal grassland of Ghana. *Tropical Grasslands,* 19(4):164–170.

Heering J.H. 1989. Initial evaluation of *Brachiaria* species. *PGRC/E–ILCA Germplasm Newsletter* 20:2–6.

Lazier J.R. 1981. Dry matter productivity of eighteen native Belizean legumes and *Codariocalyx gyroides* with Para grass *(Brachiaria mutica)* under clipping. *Tropical Agriculture (Trinidad)* 58 (3):221–223.

Rendement saisonnier en matière sèche de plantes fourragères introduites dans un site de la zone subhumide du Ghana

Résumé

La production de matière sèche de 21 légumineuses herbacées, 6 légumineuses arbustives et 8 graminées provenant du CIAT en Colombie (Amérique du Sud) a été étudiée en 1992–1993 à Pokoase, en zone subhumide du Ghana. Les qualités d'établissement et la croissance initiate de ces plantes avaient été évaluées l'année précédente sur ce même site. Parmi les légumineuses herbacées, les meilleures rendements sur les deux saisons avaient été obtenus avec *Centrosema macrocarpum* CIAT 5452 et 5713, *Centrosema acut folium* cv. Vichada et CIAT 5568, et*Stylosanthes guianensis cv.* Pucallpa et var. *pauciflora.* Parmi les graminées, les meilleures performances revenaient à *Brachiara brizantha* cv. la Libertad et Marandu et à *Panicum maximum* CIAT 673 et T 58. *Cajanus cajan* CIAT 18700 venait en tête parmi les légumineuses arbustives étudiées, les autres étant *Cratylia argentea, Codariocalyx gyroides, Flemingia macrophylla* et *Leucaena leucocephala.*

Productivité et valeur bromatologique de graminées et légumineuses fourragères en région maritime du Togo

P.K Agbemelo-Tsomafo et Y. Agbossamey

Ecole supérieure d'agronomie
Université du Benin
B.P. 1515, Lomé (Togo)

Résumé

Une étude a été mené à Kovié en zone maritime du Togo pour déterminer la productivité et la valeur bromatologique des graminées fourragères *Brachiara brizantha* CIAT 6780 (cv. Marandu) et*Panicum maximum* T58; des légumineuses herbacées *Cassia rotundifolia* (actuellement *Chamaecrista rotuhdifolia), Centrosema pascuorum* (cv. Cavalcade) et *Zornia glabra* CIAT 8279 ainsi que des légumineuses fourragères arbustives *Cajanus cajan* CIAT 18700 et *Leucaena leucocephala* CIAT 17502 (cv. Cunningham).

Le matériel étudié a été installé sur des parcelles de 2,5 × 5 m en blocs aléatoires avec un dispositif en split plot. Les données recueillies ont été principalement la production de biomasse en matière sèche sur des repousses de 3, 6, 9 et 12 semaines d'âge après une coupe d'égalisation, le potentiel de production de semences et la valeur bromatologique par le biais d'analyses chimiques.

Les résultats indiquent que les rendements en matière sèche les plus élevés ont été enregistrés sur des repousses de 12 semaines chez toutes les espèces testées. Its étaient respectivement de 8,6 et 12,6 t/ha pour *B. brizantha* et *P. maximum* chez les graminées fourragères contre 2,2 t/ha et 4,8 t/ha pour *C. rotundifolia* et C. *pascuorum* chez les lègumineuses herbacèes et 4,5 t/ha et 5,2 t/ha pour C. *cajan* et *L. leucocephala* chez les arbustes fourragers.

Cependant, â 6 semaines, *P. maximum* présente déjâ des rendements de 6,1 t/ha tandis que ceux des légumineuses herbacées C. *pascuorum* et Z. *glabra* sont supérieurs a 4 t/ha.

La teneur en protéines brutes des légumineuses herbacées diminue avec l'âge des repousses, allant de 16 et 19% â 3 semaines respectivement â 11,3 et 12,1% â 12 semaines chez Z. *glabra* et *C. pascuorum.* A 6 semaines, cette teneur est située entre 12 et 15% pour les trois légumineuses herbacées.

La prise en compte des rendements et de la valeur bromatologique des espèces étudiées permet de proposer pour *P. maximum, C. pascuorum* et Z. *glabra* une exploitation â 6 semaines afin d'optimiser les rendements et la qualité de leur fourrage. Les espèces ligneuses *L. leucocephada* et *C. cajan* devraient, quant â elles, être exploitées sur des repousses âgées de 9 semaines.

Introduction

Du matériel fourrager comprenant deux espèces graminéennes *Brachiaria brizantha* CIAT 6780 (cv. Marandu) et *Panicum maximum* T 58 , trois espèces de légumineuses herbacées *Cassia* *rotundifolia* (actuellement *Chamaecrista rotundifolia), Centrosema pascuorum (cv.* Cavalcade) et *Zornia glabra* CIAT 8279 ainsi que deux espèces de légumineuses arbustives *Cajanus cajan* CIAT 18700 et *Leucaena leucocephala* CIAT 17502 (cv. Cunninghan) a été testé en 1990–1991 pour sa productivité en matière sèche, son potentiel de production de semences et sa valeur bromatologique â Kovié, en région maritime du Togo.

Le site est situé â une altitude moyenne de 20 m et connaît une pluviométrie bimodale annuelle allant jusqu'â 1400 mm et une température moyenne annuelle d'environ 26,5 °C.

Méthodologie

Le semis a été effectué les 16, 17 et 18 mai 1990. Le dispositif expérimental était en split plot avec 3 répé titions, les espèces constituant les parcelles principales et les âges des repousses de 3, 6, 9 et 12 semaines les sous-parcelles.

Chaque parcelle comprenait quatre lignes de 5 m de long distantes de 0,5 m. L'aire d'échantillonnage était constituée par les deux lignes centrales sur une longueur de 4 m.

En plus des parcelles choisies au hasard, une parcelle additionnelle comprenant une seule ligne pour chaque espèce a été installée pour les observations relatives â la floraison et â la fructification.

Au semis, les légumineuses ont été inoculées et 4 mois après le semis, chaque parcelle de graminèes a reÇu une fertilisation de 90 g d'urée. Chaque parcelle a aussi reÇu 35 g de chlore.

Les observations en phase d'établissement ont porté sur la levée. En phase de production, les variables étaient la production de biomasse, la floraison, la production de semences et la valeur bromatologique évaluées selon la méthodologie suivante:

- Des échantillons récoltés â divers âges de repousse ont été analysés au laboratoire pour en déterminer la composition chimique. La méthode de Kjeldahl a été utilisée pour déterminer la teneur en azote; la cellulose a été déterminée par la méthode de Weende au Fibertec-System. Le dosage des minéraux a été fait par spectrométrie à émission de flamme pour le potassium (K) et le sodium (Na); par calorimétre pour le phosphore et par spectromètre à absorption atomique (Perkin-Elmer 2380) pour le calcium, le magnésium, le manganèse, le zinc, le cuivre et le fer.
- Le potentiel de production de semences a été estimé à vue d'oeil suivant une échelle de 1 à 4 (Toledo *et al.,* 1982); 1 indique l'absence ou une très faible production de semences; 2, une production de semences faible ou moyenne; 3, une production de semences moyenne ou élevée et 4, une très forte formation de semences;
- Les coupes ont été réalisées à une hauteur de 5 à 10 cm pour les légumineuses herbacées, 10 a 15 cm pour les graminées et de 20 à 30 cm pour les légumineuses arbustives.

Les données recueillies ont fait l'objet dune analyse de la variance avec le logiciel STATITCIF.

Résultats

Levée, floraison et production de semences

Les dates de levée de 50% de floraison, la durée de floraison et l'estimation du potentiel de production de semences sont rapportdes au tableau 1.

Tableau 1. *Dates de floraison et potentiel de production des semences des espéces testées.*

Espéce	Date de l'initiation de floraison	Mois de pleine floraison	Potentiel de production de semences
B. brizantha	14 sept. 1990	Sept.–déc.	4
P. maximum	26 sept. 1990	Sept.–janv.	4
C rotundifolia	13 juin 1990	Juin–août	4
C, pascuorum	27 août 1990	Aout–oct.	4
Z. glabra	12 juill. 1990	Juill–déc.	4
C. cajan	23 nov. 1990	Nov–févr.	4
L. leucocephala	16 oct. 1990	Oct–janv.	4

Date de semis : 18 mai 1990

Date de levée : Du 21 au 23 mai 1990

La levée a été rapide et homogène chez toutes les espèces testées. Elle était effective 5 jours après le semis.

Chez les graminées, B. *brizantha* et P. *maximum* ont atteint les 50% de floraison respectivement les 14 et 26 septembre 1990.

Parmi les légumineuses herbacées; *C. rotundifolia* s'est montrée très précoce car sa floraison avait déjà atteint les 50% dès le 13 juin. Elle s'est étendue jusqu'au mois d'août.

Z. glabra a aussi montré une certaine précocité et se caractérise par la longueur de sa floraison (juillet à décembre).

Les graminées et les arbustes fourragers ont eu une floraison tardive et prolongée qui s'étend à peu près sur quatre mois. Toutes les espèces étudiées ont eu un potentiel de production de semences élevé, indiquant qu'elles peuvent être facilement vulgarisées en milieu rural dans la zone maritime du Togo.

Rendements en matière sèche

Les rendements en tonnes de matière sèche par hectare en fonction de l'âge des repousses sont rapportés au tableau 2.

Tableau 2 .*Production de biomasse en fonction de l'âge des repousses (en t de MS/ha).*

	Age des repousses (en semaines)

Espéces	3	6	9	12
B. brizantha	0,9	2,9	5,9	8,6
P. maximum	1,8	6,1	8,8	12,6
C. rotundifolia	1,0	1,9	2,4	2,2
C. pascuorum	1,6	4,1	4,2	4,8
Z. glabra	1,2	4,4	3,8	4,6
C. cajan	0,2	2,2	3,2	4,5
L.leucocephala .	0,6	2,2	3,6	5,2

Ces résultats montrent que pour toutes les espèces étudiées, les rendements en matière sèche les plus élevés soot enregistrés sur des repousses de 12 semaines. Chez les graminées, *P. maximum*est le plus productif avec un rendement de 12,6 t/ha. Avec des repousses de 6 semaines, cette espèce donne déjà des rendements atteignant 6 t/ha indiquant qu'une exploitation à cet âge peut se révéler avantageuse.

Les espèces *C. pascuorum* et *Z. glabra* ont une production de matière sèche qui augmente rapidement entre 3 et 6 semaines, atteignant des rendements supérieurs à 4 t/ha au bout de 6 semaines. Entre 6 et 12 semaines, l'accroissement de la production de matière sèche est pratiquement négligeable indiquant clairement que ces espèces devraient etre exploitdes sur des repousses de 6 semaines.

Les légumineuses arbustives *C. cajan* et *L. leucocephala* ont enregistré des rendements entre 4,5 et 5 t de MS/ha sur des repousses de 12 semaines. A lâge de 9 semaines, les repousses de ces deux espèces ont des rendements respectifs de 3,2 et 3,6 t de MS/ha suggérant que les repousses de 9 semaines permettraient une combinaison fr6quence de coupe-rendement plus avantageuse.

Valeur bromatologique

La teneur en matière protéique brute (MPB) a été analysée chez les trois légumineuses herbacées. Les résultats obtenus sont rapportés au tableau 3.

Tableau 3. Teneur en matière protéique brute de *C. rotundifolia, C. pascuorum* et *Z. glabra* en fonction de Page des repousses (en %) *.*

Espèce	Age en semaines			
	3	6	9	12
C. rotundifolia	8,3	12,6	11,5	11,8
C. pascuorum	19	15,3	13,6	12,1
Z. gdabra	16	14,4	12,2	11,3

Ces données montrent que la teneur en protéines brutes diminue avec l'âge. *C. pascuorum* présente la teneur protéique la plus élevée â tous les ages des repousses.

Contrairement à la situation observée avec le taux de matière protéique brute, la teneur en cellulose brute augmente avec lâge des repousses entre 3 et 9 semaines pour les trois espèces étudiées (tableau 4).

Tableau 4. Teneur en cellulose de *B. brizantha, P. maximum* et *Z. glabra* (en %).

Espèce	Age en semaines		
	3	9	12
B. brizantha	25	35	35
P. maximum	32	35,7	35
Z. glabra	27	42	36

A 12 semaines, cette teneur s' infléchit légèrement pour *P. maximum* (de 35,7 à 35%) et de manière significative pour Z. *glabra* (de 42 à 36%). Cela est probablement dû à la présence de jeunes pousses moins riches en cellulose.

De toutes les espèes étudiées, *P*. *maximum* présente la teneur en cendres la plus élevée à tous les âges tandis que la teneur la plus faible est observée chez *C. rotundifolia* (environ 5%).

Les teneurs observées de P, K, Ca, Mg, Na, Fe, Mn, Cu, et Zn indiquent que toutes les espèces étudiées sont, à tous les âges, suffisamment riches en minéraux pour satisfaire les besoins nutritionnels des animaux.

Conclusion

Cette étude montre que les graminées *Panicum maximum* T. 58 et *Brachiaria brizantha* cv. Marandu; les légumineuses fourragères herbacées *Centrosema pascuorum* et *Cassia rotundifolia* et les légumineuses arbustives *Cajanus cajan* CIAT 18700 et *Leucaena leucocephala* cv. Cunningham sont des espèces prometteuses pour une augmentation des ressources fourragères du bétail en zone maritime du Togo.

Les résultats enregistrds indiquent qu'il est préférable d'exploiter P. *maximum, C. pascuorum* et C. *rotundifolia* lorsque leurs repousses sont ages de 6 semaines, ce qui permet d'optimiser le rapport quantité/quality du fourrage pour améliorer les rendements en production animale. Les espèces arbustives *L. leucocephala* et C. *cajan* et le cultivar Marandu de *B. brizantha* devraient quant a eux, etre exploités lorsque leurs repousses sont ages de 9 semaines.

Bibliographie

Toledo J.M., Amézquita M.C. et Pizaro E. 1982. Analyse du comportement des germoplasmes fourragers évalués par le RIEPT dans les écosystemes de savanne et forêt tropicales d'Amérique. In:*Résultats du RIEPT 1979–1982.* Publié sous la direction de E. Pizarro. CIAT (Centre international d'agriculture tropicale), Cali(Colombie). p. 429 à 447.

Performance and nutritive value of some grass and herbaceous legume forage species in the coastal region of Togo

Abstract

A study was carried out at Kovie in the coastal zone of Togo to assess the performance and nutritive value of the grass species and accessions *Brachiaria brizantha* CIAT 6780 (cv Marandu) and*Panicum maximum* T58; the herbaceous legumes *Cassia rotundifolia* (nons *Chamaecrista rotundifolia), Centrosema pascuorum cv* Cavalcade and *Zornia glabra* CIAT 8279 and the fodder shrubs/trees *Cajanus cajan* CIAT 18700 and *Leucaena leucocephala* CIAT 17502 (cv Cunningham).

The material was planted on 2.5 m × 5 m plots in a split plot design. The data recorded were mainly the dry matter production on 3,6,9 and 12 weeks old regrowths after a standardization cut; the potential for seed production and the nutritive value through chemical analysis.

The results indicate that for all the species evaluated the dry matter yields were highest on 12 weeks regrowths with B. *brizantha* and P. *maximum* producing 8.6 and 12.6 t/ha respectively, the herbaceous legumes producing between 2.2 and 4.8 t/ha for *C*. *rotundifolia* and *C*. *pascuorum* respectively and the fodder trees producing respectively 4.5 and 5.2 t/ha for *C*. *cajan* and *L. leucocephala.*

At six weeks however, the dry matter yield of P. maximum is already as high as 6.1 t/ha while at the same age, C. pascuorum and Z. glabra show yields as high as 4 t/ha.

Observed crude protein (CP), content of the herbaceous legumes decreases with increased regrowth age, from 16 and 19% at 3 weeks to 11.3 and 12.1 % at 12 weeks for Z. *glabra* and *C.pascuorum,* respectively. At 6 weeks, the CP was between 12 and 15 % for the three herbaceous legume accessions.

Considering the observed the dry matter yields and nutritive value, it is recommended that P. *maximum, C. pascuorum* and Z*. glabra* be harvested when regrowths are 6 weeks old to ensure an optimum balance between dry matter yield and nutritive value, while *L. leucocephala* and *C*. *cajan* should be harvested on regrowths aged 9 weeks.

Comparative performance during the establishment of five forage legumes in the Highland Zone of Western Cameroon

E. Tedonkeng Pamo and T. C. Mubeteneh

University of Dschang, Faculty of Agronomy and Agricultural Sciences,
Department of Animal Science, P.O. Box 222, Dschang, Cameroon

Abstract

A field study to evaluate five herbaceous legumes during the establishment phase was conducted in a Sudano-guinean zone of Cameroon. Amongst the five species *Desmodium intortum* showed rooting at internodes and reached the highest soil cover at three months after planting (66%), followed by *Macrotyloma axillare* (50%). *Neonotonia wightii* had the highest number of secondary and tertiary branches. On the whole, the species *Macroptilium atropurpureum* had the lowest value for the four recorded parameters ($P<0.05$). This preliminary evaluation showed that *Desmodium intortum* and *Macrotyloma axillare* were the most promising species.

Introduction

The expansion of the rural population, relying on a fixed land base will inevitably lead to an increase of cultivated land where land is still available, or to greater intensification of the cropping system where land is scarce. In the western highlands of Cameroon, crop farming is rapidly expanding into the mountainous rangelands of Bafou (Nzie) with slopes ranging from 30 to 60%. The cropping of marginal land with high erosivity combined with a drastic reduction of the fallow period requires research to develop a sustainable land-use system for this region.

This system should include the strategic utilisation of feed resources to optimise livestock nutrition and output. During the long dry season, the nutritive value of the natural pastures on which most livestock depend declines drastically. Herdsmen try to overcome this deficiency by exploiting crop residues. However, local feeding strategies seem inadequate as most animals lose weight. Shortage of grazing land is further reducing the possibility to maintain range-fed animals and thus dictates that feed production is increased. The common solution to scarcity of feed is to use agro-industrial byproducts such as cotton seed cake and groundnut meal. However, supplies of these feeds are inadequate for the existing ruminant population and feed prices are high and rising. For this reason, renewable sources of feed such as cultivated forage should be promoted.

Since few studies on forage legumes have been conducted in the western highland zone of Cameroon, the aim of this research, carried out at the University of Dschang main campus, was to evaluate the performance of five leguminous forage species during the establishment phase.

Materials and methods

The experimental site is located at Dschang, on a piedmont of a hill area of crystalline parent material (granite, gneiss) at an altitude of 1420 m; the slopes vary from 9% in the lower part to

16% in the upper part. The mean annual rainfall is of 1870 mm with a peak in August–September and the mean annual temperature is 17.6°C.

The field study started in April 1993 at the onset of the rains. A completely randomised design with three replications was used incorporating five species: *Macroptilium atropurpureum*, *Desmodium intortum*, *Dolichos axilaris, Macrotyloma axillare*, and *Neono*tonia *wightii*. A fine seed-bed was prepared by ploughing and harrowing. After manual scarification with sand paper, seeds of each species were planted on plots measuring 2.5 by 5 m separated by one meter strips. In each plot, four lines 0.5 m apart, were hand-seeded.

During the establishment period of three months, data on per cent soil cover, number of plants per m^2, length of primary stem and number of branches were collected monthly on plants within a 1 × 1 m quadrats placed randomly in the middle of each plot. Per cent plant cover was estimated in a 1 × 1 m frame subdivided into 25 (0.2 × 0.2 m) smaller squares, total plant soil cover being the mean of the 25 subplots. Analyses of variance was carried out on the data and differences among treatments were tested using Duncan's Multiple Range Test at 5% probability level. Changes in length of primary stems and per cent crop cover with time were also analysed.

Results and discussion

Plant population dynamics during the establishment phase are an important indicator of adaptability. Seedling density was highest for *Desmodium intortum* which outperformed the other species (P<0.05) while *Macroptilium atropurpureum* performed poorest (Table 1). Seedlings of the legumes emerged between one to two weeks after planting. This long germination period may be caused by the differential response of species to manual scarification.

Table 1. *Performance of different species with respect to the different parameters at three months after planting.*

Species	Density (Plants/m)	Plant cover (%)	Stem length (cm)	Number of branches
M. axillare	89b	50b	75a	3.9c
N. wightii	29cd	23c	48c	501b
D. axilaris	22cde	27c	30d	204d
M. atropurpureum	17de	28c	9c	1.8de
D. intortum	230a	66a	34d	1.1e

For each column, means followed by the same letters) are not significantly different at the 5% probability level.

Per cent soil cover is influenced both by plant population and leaf area of each plant. It determines to an extent the amount of runoff and soil erosion during the establishment phase. Given the high rainfall intensity in the western part of Cameroon, surface runoff may occur but with limited soil loss. *Desmodium intortum* outperformed the other species owing to its large leaf size and its high seedling density; it attained 100% cover at two months after planting. *Macrotyloma axillare* grew slowly initially but spread faster after the second month of growth reaching 50% plant cover at three months. *Neonotonia wightii, Dolichos axilaris, Macroptilium atropurpureum* had the low soil cover (P<0.05) at three months after planting (Table 1).

The length of the primary stem was greatest for *Macrotyloma axillare* and lowest in *Macroptilium atropurpureum. Neonotonia wightii* produced an average of five branches while *Desmodium intortum*showed little branching. Plant height varied between species: at three months, *M. axillare* was tallest followed by *N. wightii. M. atropurpureum* grew little in height (9 cm), nor did it branch out much. All species remained green during the first three months.

Conclusions

Legumes are highly desirable components of tropical pastures where nitrogen is a limiting factor and where there is an urgent need for increased crude protein in herbage for grazing or stall-feeding.

This preliminary evaluation showed that *Desmodium intortum* and *Macroptyloma axillare* were the most promising species. Their potential to withstand frequent harvesting for animal feed needs further evaluation.

It is of interest to note that *Desmodium intortum* and *Neonotonia wightii* root frequently at the nodes when in contact with the soil, making them aggressive competitors to weeds.

Reference

Winrock International. 1992. *Assessment of Animal Agriculture in the Sub-Saharan Africa.* Morrilton, Arkansas, USA.

Performances comparées de cinq légumineuses fourragères en phase d'établissement dans les hauts plateaux de l'Ouest-Cameroon

Résumé

Une étude a été menée en milieu réel pour évaluer cinq légumineuses fourragères en phase d'établissement dans une zone soudano-guinéenne du Cameroon. Sur ces cinq espèces, seule*Desmodium intortum* a poussé des racines aux entre-noeuds et donné la meilleure couverture du sol (66%) trois mois après le semis, suivie de *Macrotyloma axilare* (50%). *Neonotonia wightii* a eu le nombre le plus élevé de branches secondaires et tertiaires. Dans l'ensemble, *Macroptilium atropurpureum* a enregistré les valeurs les plus faibles pour les quatre paramètres étudiées (P<0,05). Il ressort de cette évaluation préliminaire que *Desmodium intortum* et *Macrotyloma axillare* sont les plus prometteuses des cinq espèces étudiées.

Evaluation of *Sesbania sesban* and *Sesbania goetzei* accessions in subhumid coastal area of Tanga, Tanzania

P.X. Kapinga, S.N. Bitende and R.C.T. Mulangila

Livestock Research Centre, P.O. Box 5016, Tanga, Tanzania

Abstract

Several *Sesbania sesban* and *Sesbania goetzei* accessions were screened for seedling survival, growth of height and diameter, forage production and nutritive value of the foliage. Out of 74 *S. sesban* and seven S. *goetzei* accessions studied, 35 *S. sesban* and two *S*. *goetzei* accessions survived up to the end of the third growing season (July 1993). Forage production was high with accessions 1303, 15020, 1215, 15018 and 1221 producing 1292, 1258, 1217, 1106 and 1086 g DM/plant, respectively. *In vitro* dry matter digestibility values averaged 68.8, 61.4 and 74.8% for leaves, petioles and succulent branches, respectively. *Sesbania* foliage when fed to freely browsing or penned goats was not readily eaten indicating a low initial acceptability.

Introduction

Sesbania species are adapted to a wide range of soils (Evans and Rotar: cited by Nzioka et al 1993) and due to their fast growth can produce large quantities of foliage (Yamoah: cited by Kusekwa et al 1993). *Sesbania sesban* and *S. goetzei* have shown great potential for fodder production as compared with the other *Sesbania species* (Nzioka et al 1993). The objective of this multilocational collaborative study was to screen several *S sesban* and *S. goetzei* accessions under different cutting regimes.

Materials and methods

The experiment was conducted at the Livestock Research Centre located in Tanga, in the subhumid coastal area of Tanzania (altitude 66 m asl; 5°15'S and 39°15' E). Rainfall is bimodal with an average of 1200 mm, falling mainly between March and June and between September and December. Mean maximum temperatures range between 30 and 33°C and mean minimum temperatures are within the 20–23°C range. Soils are predominantly sandy foams, low in organic matter, nitrogen and phosphorus with a pH of 6.0 –7.5.

A total of 74 *S. sesban* and seven *S. goetzei* accessions were received from the ILCA genebank. The seeds were sown in polythene tubes and germination was recorded after 10 days. The seedlings (of about 40 cm height) were transplanted in the field at 1.5 m × 1.5 m spacing and received four fertiliser treatment combinations: N_0P_0; $N_{20}P_0$; N_0P_{40}; $N_{20}P_{40}$. Each accession was planted in two rows of eight plants per row and replicated two times. Sets of four trees in the row received one of the four fertiliser treatments.

Parameters observed in the initial screening included seedling vigour and height before transplanting; plant incremental height at monthly intervals; incidence of pests and diseases;

days to reach 50% flowering and 50% podding; seed yield per plant; biomass yield (leaf and stem); number of harvestable branches and primary stem diameter at 20 cm above ground level.

At the beginning of the rainy season in the second year (23.3.1992), plants were cut down to 75 cm; thereafter plants were allowed to regenerate up to 120 cm canopy height. Data collection included days to reach 120 cm canopy height and the number of harvests. Other parameters included: forage yield (g DM/plant) in terms of leaves, petioles and succulent branches; plant survival rates at the end in dry season and following rainy season; *in vitro* dry matter digestibility for the first cut in the wet season and second cut in the mid dry season and palatability of the forage.

At each harvest, the fodder was separated into two portions: One portion was sun dried to record the fractions of succulent branches and separate leaves from petioles; the other portion was taken to penned goats while other goats were driven through the plots in order to assess the palatability of standing fodder.

Results and discussion

The climatic data for the two years of study are presented in Table 1. In general the amount of rainfall was less than the long term averages of 1200 mm, with a less distinct dry season (Jan–Mar) in 1991.

Table 1. *Rainfall, temperatures and relative humidity (RH) at LRC Tanga for 1991 and 1992.*

Year	1991				1992			
		Temperature(°C)				Temperature(°C)		
Month	Rainfall (mm)	max.	min.	RH%	Rainfall (mm)	max.	min.	RH%
Jan.	88	33	22	64	–	32	22	63
Feb.	88	33	22	66	–	32	23	60
Mar.	163	33	24	62	7	34	23	56
Apr.	114	32	22	64	317	31	23	71
May	309	30	22	72	351	30	22	70
June	55	29	21	60	74	29	21	68
July	13	29	19	59	62	27	20	68
Aug.	37	29	19	60	43	28	18	61
Sep.	35	30	20	62	63	29	20	63
Oct.	45	32	21	59	39	31	20	59
Nov.	102	32	23	67	108	30	22	68
Dec.	82	32	22	68	88	31	21	68
Total/mean	1131	31	21	64	1250	30	21	65

Germinating rates and seedling height

The overall germination rates of all accessions were poor with an average of 30.5±10.3, ranging from 12% to 51% for accessions no. 1284 and 1191, respectively. There was no difference (P>0.05) in germination between S. *sesban and S. goetzei* accessions (Table 2). Average seedling heights at four and eight weeks in the nursery were 6.7 and 37.2 cm, respectively (Table 2). *S. sesban*accessions grew faster than *S. goetzei* accessions.

Table 2. *Germination rates of Sesbania species and seedling heights at four and eight weeks in the nursery.*

Species	Number of accessions	Mean germination (%)	Average height (cm)	
			4 wks	8 wks
S. sesban	74	30.6 ±10.5	7.5 ± 3.8	39.9 ± 19.9
S. goetzei	7	29.0 ± 8.8	5.8 ± 2.9	34.5±16.8
Overall	81	30.5 ±10.3	6.7	37.2

Incidences of pests

Observations on pests incidences were done regularly. In June 1991 *S. sesban* was attacked more often than *S. goetzei* (Table 3), but in July 1992, all accessions were attacked.

Table 3. *Incidences of pest scored in June 1991 and July 1992.*

Year	*Species*	Scores						Mean score
		0	1	2	3	4	5	
1991	*S.sesban*	13	23	13	13	9	3	1.9
	S. goetzei	5	1	0	1	0	0	0.6
1992	*S.sesban*	0	15	18	23	8	2	2.1
	S. goetzei	0	0	2	0	1	0	2.7

0 = no attack; 5 = heavy attack.

The serious pests were *Mesoplathys ochroptera* and *Phallophage* sp whose adults and larvae were eating leaves and stem bark.

Growth in height

The plant heights were measured at 16 and 24 weeks of age in the first year. At 16 weeks of age, the plant heights differed (P<O.U1) between accessions, between the two species and among the fertiliser treatments (Table 4). Accession 1300 produced the tallest plants (2.4 m) while accession 1228 had the smallest plants (0.9 m). *S. sesban* accessions were taller on average than S. *goetzei*accessions (1.53 vs 1.25 m).

Table 4. *Statistical analysis of incremental heights, number of harvestable branches and stem diameter of* Sesbania *accessions at various ages.*

Variable	Plant height (cm)		Branches (no.)		Diameter (cm)
	16 wks	24 wks	12 wks	24 wks	22 wks
Accessions	* *	* *	* *	* *	* *
Species	* *	NS	* *	NS	NS
Fertilisers	* *	NS	NS	NS	* *

** P<0.01; NS : non-significant (P>0.05).

The application of nitrogen fertilisers was beneficial to the plants up to 16 weeks of age (Table 5). At 24 weeks of age, the plant heights differed significantly (P<0.01) between accessions whereas fertiliser applications had no effect (Table 4 and 5). Variability in height was large ranging from 1.1 to 3.3 m. However, 67% of the accessions grew to 1.5–2.5 in and another 25% were >2.5 m (Table 6).

Table 5. *Effects* of *fertilizers on plant height, harvestable branches and stem diameter.*

Variable	Plant height (m)		Harvestable branches		Stem diameter (cm)
	16 wks	24 wks	12 wks	24 wks	22 wks
N_0P_0	1.43[b]	2.01	23.8	27.9	4.2[b]
N_0P_{40}	1.44[b]	2.13	24.2	28.0	4.6[a]
$N_{20}P_0$	1.58[a]	2.23	23.9	28.1	4.3[b]
$N_{20}P_{40}$	1.48[a]	2.17	25.1	29.4	4.6[a]

In each column, means followed by different letters are significantly different (P<0.05).

Table 6. *Frequency distributions (%) of height (m) at 24 weeks, stem diameter (cm) at 22 weeks of growth and cumulative foliage biomass per plant (of six harvests) of* Sesbania sesban *accessions.*

Height (m)	%	Diameter (cm)	%	kg M/plant	%
<1.5 m	8	<4.0	34	<0.3	21
1.5–2.0	30	4.0–5.0	50	0.3–0.6	53
2.1–2.5	37	5.1–6.0	10	0.6–1.0	179
>2.5	25	>6.0	6	>1.0	
Sample (N)	67		68		53

Harvestable branches

The number of harvestable branches per plant were counted at 12 and 24 weeks of age. At both ages the number of branches were significantly (P<0.01) affected by accession but not by fertiliser application (Table 4).

S. sesban (P<0.01) had more branches than *S. goetzei* accessions at early age, but at later stage, number of branches were similar. At 24 weeks of age accessions 1193 showed the highest number of branches per plant (42) and accession 1228 the lowest (11).

Primary stem diameter

The stem diameters at 20 cm above ground level at 22 weeks of age varied (P<0.01) with accessions and with fertiliser applications. However, mean stem diameters between species were not (P>0.05) different (Table 4). The largest diameter (6.7 cm) was recorded for acc. 1300, closely followed by 1295 (6.5), 1203 (6.0) and 1177 (6.0). However, most accessions (60%) had diameters between 4 and 6 cm (Table 6).

Survival rates

The experiment started with 81 Sesbania accessions comprising of 74 *S. sesban* and seven *S. goetzei* accessions. All accessions survived the first year (1991) but some died in the second year following defoliation. Eleven S. *sesban* accessions and one *S. goetzei* accession were completely destroyed by a construction firm clearing the electric grid, and therefore did not enter the second evaluation stage; likewise, 30 *S. sesban* and *S. goetzei* accessions had one replicate destroyed. Thus., at the end of the first wet season of the cutting experiment (July 1993), 33 *S. sesban* and 2 *S. goetzei* accessions survived.

High survival rates were recorded for acc. 1303 (66%) and 1221 (60%). The other entries recorded below 50% survival rates. Though recognised as a potential feed resource (ILCA 1986) it seemed*Sesbania* plants do not tolerate frequent and severe defoliation, particularly when started at an early (<1 year) age.

Forage yield

Forages were harvested whenever 50% of the plants reached a canopy height of 120 cm. During 1992, six harvests were recorded at 37, 35, 68, 51, 54 and 56 days giving a mean cutting interval of 50 days. The long interval of 68 days corresponded with heavy pest infestations which temporarily halted growth (Table 3). Forage yields are given in terms of leaves, petioles and succulent branches. Total forage of leaves and petioles was highest in S. *sesban* ac. 1303, 15020, 1215, 15018 and 1221 which recorded 1.29,1.26,1.22,1.11 and 1.09 kg DM per plant per year, respectively. On average*S. sesban* produced more forage than *S. goetzei* (Table 7). Few accessions produced <0.1 kg of forage, whereas over half yielded between 0.3 and 0.6 kg/plant (Table 6).

Table 7. *Forage yield (g DM/plant) and* in vitro *dry matter digestibility (IVDMD)* of *forage components.*

Species	Forage yield (g DM/plant)			IVDMD (%)		
	Leaves	Petioles	Branches	Leaves	Petioles	Branches
S. sesban	424	89.0	160	69.0	61.7	72.9
S. gotzei	330	54.0	90	68.5	61.1	76.6
Mean	377	71.5	125	68.8	61.4	74.8

In vitro dry matter digestibility (1VDMD)

Dry matter digestibility of the forage ranged from 47.6 to 80.2% for leaves, from 40.8 to 74.2% for petioles and from 54.5 to 80.8% for succulent branches (Table 7). Most forages were high in digestibility. There was no significant (P>0.05) difference in digestibility between *S. sesban* and *S goetzei* accessions. Succulent branches had significantly higher (P<0.05) digestibility than leaves and petioles (Table 7 and 8).

Table 8. *Frequency distribution (%) of* in vitro *dry matter digestibility (IVDMD in % DM) of leaves, petioles and branches of 53* Sesbania sesban *accessions.*

IVDMD	Leaves	Petioles	Branches
< 60	8	36	10
60–70	45	57	32
70–75	28	7	21
>75	19	–	75

a Leaf and petiole (see Table 7).

Palatability

The fodder was not eaten up by the goats whether grazing free choice in plots nor brought as cut-and-carry fodder to housed goats. Goats might have consumed the fodder if kept starving for longer period.

Conclusions

The major problem of *Sesbania* species were pest infestation and unpalatability of the fodder. If accessions could be screened for these two attributes there is little doubt that *Sesbania* could be a potential feed resource for future use.

References

ILCA (International Livestock Centre for Africa). 1986. *ILCA Annual Report* 1985/86. ILCA, Addis Ababa, Ethiopia.

Kusekwa M.L., Msafiri D.N., Mwilawa A.J. and Ngowi M.D. 1993. Evaluation of Sesbania species in semi-arid central Tanzania. In: Kategile J.A. and Adoutan S.B. (eds), *Collaborative Research on*Sesbania *in East and Southern Africa.* Proceedings of an AFRNET Workshop, held in Nairobi 9–14 September 1991.

Nzioka S.M., Menin L.K. and Dzowela B.H. 1993. The evaluation of *Sesbania sesban* var *nubica* and *S. goetzei* in a semi-arid environment in eastern Kenya. In: Kategile J.A. and Adoutan S.B. (eds),*Collaborative Research on* Sesbania *in East and Southern Africa.* Proceedings of an AFRNET Workshop, held in Nairobi 9–14 September 1991.

Evaluation d'acquisitions de *Sesbania sesban* et *Sesbania goetzei* dans la région côtière subhumide de Tanga (Tanzanie)

Résumé

La viabilité des plantules, la croissance en hauteur et en diamètre, la production fourragère et la valeur nutritive du feuillage de plusieurs acquisitions de *Sesbania sesban* et *Sesbania goetzei* ont été étudiées. Sur les 74 acquisitions de *S. sesban* et les 7 acquisitions de *S. goetzei* évaluées, 35 *S. sesban* et 2 *S. goetzei* ont survécu jusqu'à la fin de la troisième saison de croissance (juillet 1993). La production de fourrage a été é1eve, avec des chiffres de 1292, 1258, 1217, 1106 et 1086 g de MS/plante respectivement pour les acquisitions 1303,15020,1215,15018 et 1221. Les taux de digestibilité *in vitro* de la matière sèche (DIVMS) atteignaient en moyenne 68,8; 61,4 et 74,8% respectivement pour les feuilles, les pétioles et les jeunes branches. Qu'elles soient présentées aux chèvres en pâturage libre ou au piquet, les feuilles de *Sesbania* n'ont pas été consommées facilement, ce qui indique un faible taux d'acceptabilité initiale.

Data collection and evaluation of Sesbania in southern Africa

J. Ndung'u

ICRAF, MPT-GRC
P.O Box 30677, Nairobi

Abstract

This paper reports on a meeting held in November 1992 in Lilongwe (Malawi) to set the stage for collection activities of *Sesbania sesban* and related species in southern Africa. The surveys are a collaborative venture involving ICRAF, IBPGR and national institutions in Botswana, Namibia, Zambia and Zimbabwe in close association with ILCA and its feed resources network (AFRNET). Administrative arrangements are discussed dealing with funding, sharing of responsibilities between the collaborating institutions. A pilot survey and associated training have been organised to facilitate the smooth running of the larger scale collections that are to follow. Screening and evaluation of the collected material in several testing sites was discussed.

Introduction

In November 1992, the ICRAF Multipurpose Tree Germplasm Resource Centre (MPT-GRC) held a meeting in Lilongwe (Malawi), to set the stage for collection surveys of *Sesbania sesban* and its close relatives in southern Africa. The surveys were planned as a pilot exercise for the GRC, to develop a model for future collection activities for multipurpose trees (MPT's). Twenty-four participants from five SADC countries (Botswana, Namibia, Zambia and Zimbabwe) attended the workshop. There was also a representative from the SADC regional genebank, SADC Tree Seed Centre Network, IBPGR and ILCA. In the meeting, ICRAF consulted key scientists and policy makers from the region to formulate the collection strategy and work out its modalities. A summary of the outcome of the working sessions is attached in Annex 1. One of the recommendations was to conduct a practical training workshop for the collectors immediately before the collection surveys which were proposed to begin in May 1993. This workshop was held in Harare in April 1994 in association with ILCA and IBPGR; the surveys commenced soon thereafter in all five countries.

Why *Sesbania*?

Sesbania sesban has shown marked promise in agroforestry technologies such as soil improvement in relay cropping systems. It is of primary interest to ICRAF as a multipurpose species for improving fallow land, production of stakes and firewood. The only systematic collections of *Sesbania* were carried out by ILCA in eastern Africa (mainly in Tanzania in 1987) and yielded 163 accessions of 12 *Sesbania* sp. The ILCA collections showed large variations in growth and biomass production. In SADC countries, particularly in Malawi and Tanzania, there is ample scope for further selection requiring efforts to evaluate and quantify this genetic variation.

This collection was focused on southern Africa because there are indications that provenances from this region are both longer-lived, and higher yielding than the East African accessions. Besides perenniality, there appears to be germplasm in southern Africa with cold tolerance, drought hardiness, and good coppicing ability. This collection is therefore a logical extension of the earlier ILCA surveys. The ICRAF MPT-GRC has already in place a well established regional institution: the southern branch of AFRENA (Agroforestry Research Network for Africa), making the coordination of collection activities easy and effective.

Methodology

Administrative arrangements

The collection effort involved a number of national institutions including national genebanks, tree seed centres, agricultural research institutes, national herbaria, Ministries of Agriculture, as well as conservation-oriented NGO's. International coordination of regional collection activities was done through ICRAF headquarters in Nairobi. The actual collections were carried out by national scientists with participation of scientists from ICRAF, ILCA and IBPGR. Vehicles and equipment were supplied by the national institutes, whereas ICRAF funded the collection activities.

The collected seeds were divided according to the agreements set out during the planning workshop, with a portion of the seed remaining in the country of origin, and another portion being deposited in the SADC regional genebank. Material for evaluation was sent to ILCA's forage genetic resources unit in Addis Ababa, who is holding the ICRAF germplasm material until the GRC facility in Nairobi is operational. Most of the seed has already been sent back to the SADC countries for evaluation.

Collection strategy

The main focus of the collection was on *Sesbania sesban* and its perennial/biennial woody close relatives. We also did opportunistic collections of other *Sesbania* species. The sampling strategy focused mainly on rivers and river catchments, supplemented by attitudinal transects. We targeted a minimum of 50 trees per population, selecting sample targets spaced at no less than 20 m apart. We wished to collect at least 500 g of seed per accession so that the seed could go straight into evaluation without requiring a multiplication phase. Table 1 indicates the total number of accessions acquired.

Table 1. *Total number of accessions acquired in the Sesbania collection in southern Africa.*

	Botswana	Malawi	Namibia	Zambia	Zimbabwe	Total
S. Sesban	–	13	2	6	13	34
S. macrantha	–	2	–	6	1	9
S. bispinosa	–	3	1	–	10	14
S. goetzii	–	1	–	–	–	1
S. rostrata	1	2	–	–	1	4
S. tetraptera	–	3	–	1	1	5
S. corulescens	–	–	–	2	1	3
S leptocarpa	–	2	–	–	6	8
S. brevipeduncula	–	–	–	–	2	2

S. pachycarpa	–	–	3	–	–	3
S. cinerescens	–	–	6	7	–	13
S. macowaniana	–	–	2	_	–	2
S. microphylla	–	–	2	1	–	3
S. sphaserosperma	–	–	4	–	_	4
Sesbania sp	1	–	–	–	–	1
Total	2	26	21	23	35	107

Species and provenance evaluation trials

The multi-locational evaluation of *Sesbania sesban* provenances and related species from southern Africa is being coordinated by ICRAF-SA-AFRENA at eight sites: Shinyanga (Tanzania), Domboshawa (Zimbabwe), Chalimbana and Chipata (Zambia), Chitedze and Zomba (Malawi), Muguga and Maseno (Kenya). The overall objective is to record the growth and production of *Sesbania sesban* and related perennial species in different locations to compare growth rates, studying genotype × environment interactions and selecting suitable accessions for various agroforestry technologies. Six of the best performing accessions from the previous ILCA collections have been included in the evaluation trials as controls.

These trials are being laid presently and will run until January 1995.

Possible evaluation by AFRNET[1]

1. Partly an extract from a presentation made by Dr J. Ndikumana, AFRNET Coordinator, during the planning meeting.

In 1991, AFRNET, which has taken over the PANESA activities, felt it was time to review the *Sesbania* research results and plan for the future.

A workshop was therefore organised in September 1991 in Nairobi with the following objectives:

- To present research results from the different sites
- To compare data within and across ecozones
- to develop standardised methodologies for future collaborative research.

A general summary of the trends of the data presented shows that:

- Germination was high at all sites and the survival rates of the plants after transplanting was satisfactory
- Plant height and stem diameter (at 20 cm height) varied considerably between accessions, although the same accessions appeared to do well across sites
- The *Mesoplatys ochoptera* beetle was the most important pest but its infestation was seasonal and varied considerably between years. However, attacked plants recovered rapidly. Nematode attacks were reported at Bunda in Malawi
- Leaf and stem biomass yield per tree varied widely but there was a strong positive relationship between the two parameters

- While days to flowering differed between lines, *Sesbania sesban* generally produced plenty of seed indicating that seed production and supply may not be a constraint
- Some of the collections from Tanzania were taller at sites with a high rainfall than at sites with low rainfall. Responses to N fertilisers were limited to the initial stage of growth
- Most *Sesbania* accessions did not coppice well when all branches were cut; however, the few lines that coppiced well need follow-up research.

From this summary, it appears that the short lifespan of *Sesbania* is a major negative trait constraining its value in farming systems as a source of fodder, particularly in the semi-arid zone. The workshop participants agreed to pursue the evaluation process of *Sesbania* and identify a number of issues for further collaborative research, concentrating on cutting management, as well as utilisation of *Sesbania* in feeding packages.

Conclusions

ICRAF is committed to collaborate with AFRNET. There may be opportunities for linking in with the ongoing AFRNET evaluations of different accessions, as many sites are used by both networks. ICRAF needs to develop a comprehensive list of descriptors to characterise the material, especially in respect to animal feed potential; collaboration in this area should be pursued.

Annex 1. Summary outcome of working sessions

1. W.S.1 Collaboration in collection

   (a) All collection and export authorisations are to be secured through the Chairperson, Plant Genetic Resources Committees (PGRC) for each participating country.

   (b) Likely personnel for a collecting team will consist of 1 driver, 1 ICRAF staff and two nationals. PGRCs to select appropriate nationals with preference for those from forestry groups.

   (c) Funding by ICRAF will be limited to petrol, travel and perhaps mileage allowances at standard ICRAF rates.

   (d) Training will be done prior to and during collection surveys, which are planned from April 1993 onwards.

2. W.S.2 Collection strategy and methodology

   (a) The main focus will be on *Sesbania sesban* and its perennial close woody relatives. However, opportunistic collections of other species should be pursued.

   (b) Sampling strategy: ICRAF to develop a sampling strategy to explore river systems. Nationals should identify specific collection sites.

   (c) Bulk collection from 50–100 trees per site for as many provenances as possible.

(d) Modified IBPGR field sheets are preferred, but should include ethno-botanical windows.

(e) Rhizobia nodules, pest agents and diseases should be collected and identified at research centres within the region.

(f) Herbarium collections (a minimum of three sets per tree to represent a provenance) are required.

3. W.S.3 Utilisation and conservation

(a) Conservation, mainly *ex situ,* but collection teams could recommend to the Chairperson PGRC that *in situ* conservation be undertaken as appropriate collection.

(b) Three main groups area to divide and store seed: SRGB for base collections; national gene banks and ICRAF/ILCA for active and base.

(c) Sovereign rights: The principle applies that seed is to be shared only within the SADC region unless specified otherwise by the Chairman of National PGRC. Individual countries should control seed movement outside SADC. A carefully worded application is needed.

(d) Trials: Germplasm material is needed firstly for characterisation trials. This will facilitate a reduction in provenance numbers destined for genotype/environment trials across the SADC region. AFRNET and AFRENA are among logical user groups. After completion of the characterisation process there will be a need to hold another planning workshop to determine actual cooperators and plan appropriate field trial strategies.

Collecte des données et évaluation de Sesbania en Afrique australe

Résumé

Cette communication présente le rapport des travaux dune réunion organisée en novembre 1992 à Lilongwe (Malawi) pour définir le cadre d'activités de collecte d'acquisitions de *Sesbania sesban* et d'espèces apparentées en Afiique australe. Les enquêtes ont été menées de concert par l'ICRAF, le Conseil international des ressources phytogénétiques (IBPGR) ainsi que des institutions nationales du Botswana, de la Namibie, de la Zambie et du Zimbabwe en étroite collaboration avec le CIPEA et son Réseau africain de recherche sur les aliments du bétail (AFRNET). Les mécanismes institutionnels ont été examinés, notamment en ce qui concerne le financement des activités et la répartition des responsabilités entre les divers partenaires. Une étude pilote a été effectuée et un stage de formation a été organisé dans ce domaine pour faciliter les activités futures de collecte à grande échelle envisages. La sélection et l'évaluation du matériel récolté sur plusieurs sites d'essai ont également été décrites.

Forage Crop Production and Management

The effects of herbaceous legume intercropping and mulching on the productivity of Napier grass *(Pehnisetum purpureum)* and total forage yield in coastal lowland Kenya

J.G. Mureithi [1] and W. Thorpe [2]

[1]Kenya Agricultural Research Institute, Regional Research Centre
P. O. Box 16, Kikambala, Kenya
[2]International Livestock Centre for Africa, P. O. Box 80147, Mombasa, Kenya

Abstract

Four herbaceous legumes, *Clitoria ternatea, Macroptilium atropurpureum, Macrotyloma axillare* and *Stylosanthes guianensis*, recommended for the higher rainfall areas of coastal lowland Kenya, were evaluated for their suitability for intercropping with Napier grass var Bana. Mean annual rainfall during the experiment was 1180 mm. In May 1989 Napier cuttings were planted at 1 m × 0.5 m spacing, followed by legume sowing between the Napier rows about one week later. In early September 1989, herbage was harvested at 10 cm or 30 cm above ground when the Napier canopy was 1 m tall. Within 12 months six harvests were taken. Neither *Stylosanthes guianensis* nor *Macrotyloma* axillare survived the first year of the study. Average grass-legume yields of the first six harvests of*Clitoria ternatea* and *Macroptilium atropurpureum* were 6.4 and 5.9 t DM/ha, respectively, and total cumulative forage yields were 30.0 and 29.5 t/ha, respectively, neither being significantly different (P>0.05). Subsequently *Macroptilium atropurpureum* died in most plots, while only *Clitoria ternatea* survived and remained productive.

In a second phase, the effect on forage production of intercropping Napier with *Clitoria ternatea* and of mulching Napier with feed refusals (mostly of Napier) were compared. Mulch application began on 24/9/90, and by 24/2/93 nine harvests of the mulched plots gave a cumulative Napier DM yield of 42.0 t/ha, which was higher (P<0.001) than the 26.1 t DM/ha of the control treatment (no mulch and no intercrop). Intercropped Napier yielded 23.4 t/ha and the Clitoria 6.1 t/ha, a total of 29.5 t DM/ha. Mulching had a significant effect on persistence of Napier stands. Height of cutting had no effect on yield components except in the 2nd phase, when a lower cutting height increased yields (P<0.001).

Clitoria ternatea can be recommended in the coastal lowlands as it is a high yielding and persistent legume which combines well with Napier grass var Bana. The intercropping significantly increased total DM yield by 13%, and increased nitrogen yield (and therefore nutritive value) by approximately 80%. To maximise Napier production, mulching is recommended as it increased Napier DM yield by 60%. The importance of including an agronomic evaluation in production systems in the systematic assessment of forage genetic resources was demonstrated.

Introduction

In common with other parts of coastal lowlands in East Africa, the coastal region of Kenya has great potential for dairy development, being stimulated by an unsatisfied demand for fresh milk and other dairy products from a rapidly growing urban and rural population. Since 1980, Kenya's Ministry of Agriculture and Livestock Development through its National Dairy Development Project (NDDP) has encouraged smallholder farmers in the region to keep dairy cows. The NDDP recommended Napier grass as the basal forage for stall-fed cows. Despite NDDP's efforts, milk production in most units has remained low. For example, a survey of NDDP farms in Kilifi District by van der Valk (1988) showed that average daily milk yield was <8 kg. These low yields were attributed to inadequate dry matter intake and lack of cash to purchase protein and energy concentrates.

A suitable fodder grass/legume mixture can address these constraints because compared to a pure grass stand, grass/legume mixtures have the potential to produce higher total dry matter yield of higher quality, suppress weeds and improve soil fertility (Goldson 1978). The experiment reported here was initiated to identify legume species that would form sustainable associations with Napier grass. The experiment was carried out as part of a collaborative programme between the Kenya Agricultural Research Institute (KARI) and the International Livestock Centre for Africa (ILCA). This research begun in 1988 and aims at developing feeding systems for smallholder dairy farms in the coastal lowlands.

Materials and methods

Site description

The study was carried out at KARI's Regional Research Centre (R.R.C.) Mtwapa, Coast Province, Kenya (3°36' S; 39°44'E and 15 m asl). The agro-ecological zone at the Centre is coastal lowland 3 (CL3), as described by Jaetzold and Schmidt (1983), which has a long cropping season (April to June) and an unreliable short cropping season (October to December). The mean annual rainfall from 1969 to 1991 was 1200 mm: The potential evapo-transpiration is estimated to be 1470 mm (Siderius and Muchena 1977) indicating a negative annual water balance. During the same period mean monthly minimum and maximum temperatures were 22°C and 30°C, respectively. Soils had a pH-$H_2$0 of about 6.9, were moderately well drained sandy clay to clay with a sandy surface, and were classified as Orthic Ferralsols/Ferric Acrisols (Batjes 1980). They are characterised by very low levels of macro-nutrients especially nitrogen and phosphorus, low organic matter, canon exchange capacity and are prone to erosion. However, spits at the experimental site were moderately high in organic matter (1.60%), nitrogen (0.06%) and other macro-nutrients because the land was kept fallow for about six years.

Treatments and design

Four legumes recommended for the coastal region by past work (FAO 1981) were used in this experiment: e.g. *Clitoria ternatea, Macroptilium atropurpureum, Macrotyloma axillare* and *Stylosanthes guianensis.* Since in cut-and-carry systems cutting height is known to affect the productivity of forage species, particularly Napier grass (Goldson 1978), two heights were evaluated; both Napier and the legumes were harvested at 10 or 30 cm above the ground whenever the Napier reached a height of about 1 m. The experiment therefore had eight treatment combinations (4 companion legumes × 2 cutting heights). A randomised complete block design with three replications was used. The size of the main plots was 8 × 6.5 m and the net plot 6 × 4.5 m.

Methodology

Napier grass variety Bana was used which is recommended for the region (FAO 1981). It was established from stem cuttings about 30–45 cm long with three nodes and 2.5 internodes. They were planted at an angle of 45° to the ground with two nodes buried and the third above ground level at a spacing of 1 m between and 0.5 m within rows. The Napier population was therefore 20,000 stools/ha. Legume seeds were drilled between Napier rows at rates ranging from about 2 kg/ha for small-seeded legumes (e.g. Stylosanthes) to about 4 kg/ha for larger-seeded ones, e.g. Clitoria. At planting, phosphorus was applied at the rate of 20 kg of P/ha in the form of triple superphosphate.

Napier cuttings were planted on 17.5.89, the legumes were sown about one week later. In July 1989 the forages were cut back to allow for a uniform regrowth. A large number of the original Napier cuttings (>50%) did not take due to a fungal infection and gapping was done using rooted splits. Weeding was done regularly to aid establishment. Napier and the legumes were harvested together when Napier reached a height of about 1 m. Forage samples were taken at every harvest for a dry matter and chemical analysis, and for *in vitro* dry matter digestibility. Harvesting began in September 1989.

When *S guianensis* disappeared after the second harvest, *M.* axillare after the fifth harvest, and *M. atropurpureum* died out after the sixth harvest, the design and the objectives of the experiment were subsequently modified to include mulching as an additional treatment. In the region, the extension service recommended mulching of crops for soil moisture conservation and the improvement of soil fertility. Similarly, in cut-and-carry dairy systems, it is recommended that feed refusals or other mulch be applied to Napier fields. The Napier plots in which the legume species had disappeared provided an opportunity to compare the effect on forage production of mulching with feed refusals (mostly of Napier) and of intercropping with *Clitoria ternatea.* The plots previously sown to*Macrotyloma* were randomly selected for the mulching treatment and the *Stylosanthes* plot were maintained as control (no mulch) plots. The *Macroptilium* plots were discarded. Mulch application began on 24.9.90. On average 10 t/ha of mulch dry matter was applied after each harvest. After the third harvest feed refusals were not available and dry Napier grass forage was used as mulch.

Results

Results of the initial six harvests when most legumes were present are shown first, followed by the results of the subsequent nine harvests when mulching and intercropping with *Clitoria* were the main treatments.

Effects of intercropping Napier with four legumes species harvested at two cutting heights

Yields of Napier and total fodder yields (Napier + legume) were not affected by the intercropped legume species when yields were cumulated over the six harvests during the first 12 months (Table 1); the mean annual fodder yield was 24.4±0.98 t dry matter/ha. Although total fodder yield was not affected by the legume species, the legume forage yields were significantly

(P<0.001) different with*Clitoria* yielding highest (6.4 t DM/ha) and *Stylosanthes* lowest (1.3 t DM/ha).

Table 1. *The effects* of *intercropping Napier with four legume species and of two cutting heights on the cumulative yield components of six harvests taken between September 1989 and September 1990.*

Treatment	Dry matter yield t/ha		
	Napier	Legume	Total
Legume species			
Clitoria ternatea	23.6	6.4	30.0
Macroptilium atropurpureum	23.6	5.9	29.5
Macrotyloma axillare	24.8	3.7	28.5
Stylosanthes guianensis	25.6	1.3	26.9
SED	1.68	0.68	1.75
F test prob.	NS	***	NS
Cutting height			
10 cm	26.6	4.8	31.4
30 cm	22.2	3.9	26.1
SED	1.19	0.48	1.24
F test prob.	* *	NS	* * *

** P<0.01; *** P<0.001.

These large differences in the legume cumulative DM yields were primarily due to their varying ability to persist as companion crops with Napier at this high intensity of harvesting. As shown in Figure 1*, S. guianensis* disappeared after the second harvest principally as a result of anthracnose attacks. *M. axillare* died out after the fifth harvest, probably because it was not suited to frequent harvesting and was unable to climb the Napier tillers effectively to compete for light. For the same reasons, *M. atropurpureum* died out after the seventh harvest. Thus, by Sept. 1990, less than 18 months after planting, only *Clitoria ternatea* persisted as an intercrop in the forage system. Harvesting at 10 cm above the ground gave higher Napier yields (P<0.01) than cutting at 30 cm height (Table 2). As the legume was not affected by cutting height the lower height gave total greater fodder yields (P<0.001).

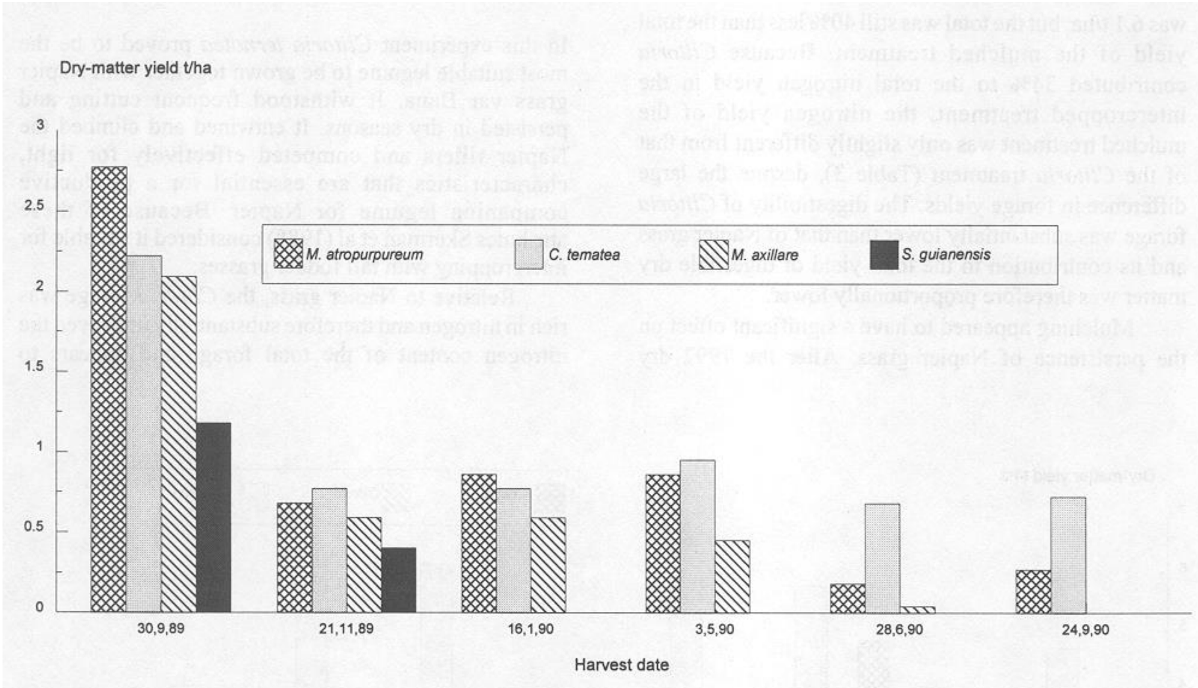

Figure 1. *The fodder yield of four legume species grown in association with Napier grass, 1989–1990.*

Table 2. *The effects of mulching, intercropping Napier with* Clitoria, *and cutting height on the cumulative fodder yield components of nine harvests taken between Dec. 1990 and Feb. 1993.*

Treatment	t DM/ha		Total
	Napier	Legume	
Control	26.2	–	26.2
Clitoria	23.4	6.1	29.5
Mulching	42.0	–	42.0
SED	2.06.	–	***
F test prob.	***		
Cutting height			
10 cm	31.2	6.9	33.5
30 cm	29.9	5.3	31.7
SED	1.68	1.03	1.88
F test prob.	NS	NS	NS

*** P<0.001; NS not significant

Effects of mulching, intercropping with clitoria and cutting height

Mulching of Napier grass gave the highest forage yield in each of the nine harvests taken between December 1990 and February 1993 (Figure 2). The cumulative fodder DM yield/ha of the mulched Napier was over 60% greater than (P<0.001) the control and also higher than that of napier intercropped with Clitoria (Table 2).

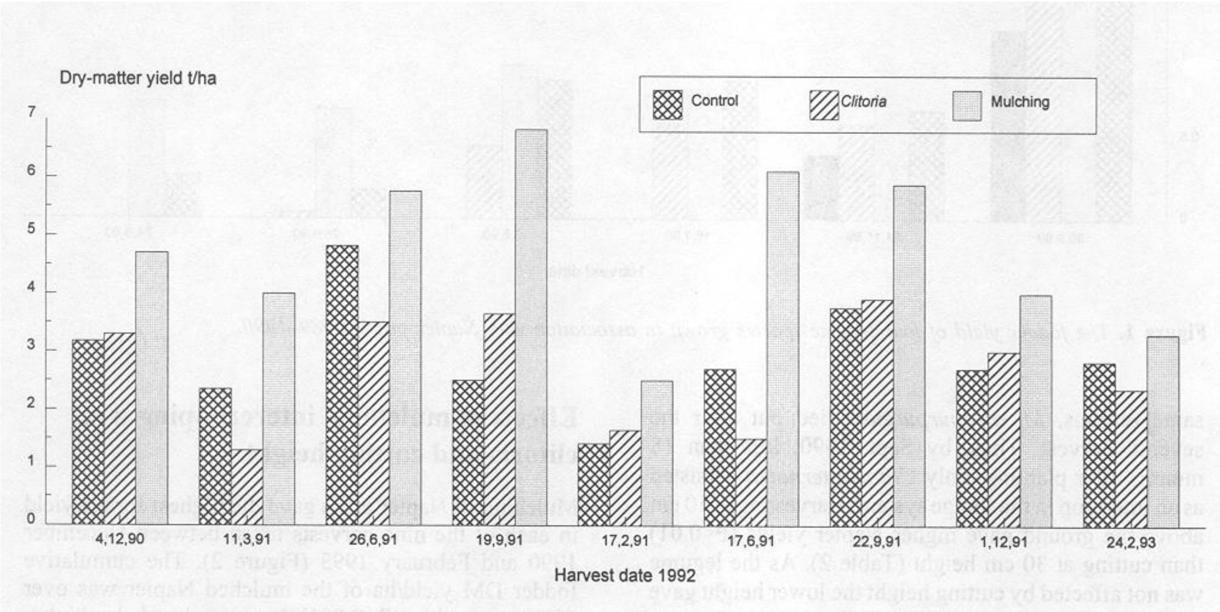

Figure 2. *The effects of mulching and intercropping with* Clitoria ternatea *on the fodder yield of Napier grass, 1989–1993.*

Compared to the no-mulch control, intercropping with *Clitoria* reduced Napier yields in three harvests. (Figure 2). In the other harvests, the yields of intercropped Napier were as high as in the control treatment while in September 1991 Napier yields were higher than in the control.

The contribution of *Clitoria* fodder to total yield was 6.1 t/ha, but the total was still 40% less than the total yield of the mulched treatment. Because *Clitoria* contributed 34% to the total nitrogen yield in the intercropped treatment, the nitrogen yield of the mulched treatment was only slightly different from that of the *Clitoria* treatment (Table 3), despite the large difference in forage yields. The digestibility of *Clitoria* forage was substantially lower than that of Napier grass and its contribution to the total yield of digestible dry matter was therefore proportionally lower.

Table 3. *The effect of mulching and intercropping Napier grass with* Clitoria *on yields of nitrogen and digestible dry matter (DDM).*

Treatment	Napier	Legume	Total
Nitrogen yield (kg/ha)[b]			
Control (0.79)[b]	207	–	207
Clitoria (1.00)	234	122	356
Mulching (0.91)	382	–	382
DDM yield (t/ha)			
Control (55.6)	14.6	–	14.6
Clitoria (55.9)	13.1	2.1	15.2

Mulching (55.9)	23.5	–	23.5

[a] The percentage nitrogen content and digestible dry matter (DDM) was 2.00 and 34.4%, respectively.

[b] Figures in parentheses are the percentage nitrogen content and digestible dry matter of Napier grass harvested on 26th June 1991.

Mulching appeared to have a significant effect on the persistence of Napier grass. After the 1992 dry season (January–April), the survival of Napier stools in the mulching and *Clitoria* intercropped treatments was 63% and 34%, respectively, compared to 48% in the control treatments.

Discussion and conclusions

In this experiment *Clitoria ternatea* proved to be the most suitable legume to be grown together with Napier grass var Bana. It withstood frequent cutting and persisted in dry seasons. It entwined and climbed the Napier tillers and competed effectively for light, characteristics that are essential for a productive companion legume for Napier. Because of these attributes Skerman et al (1988) considered it suitable for intercropping with tall fodder grasses.

Relative to Napier grass, the *Clitoria* forage was rich in nitrogen and therefore substantially improved the nitrogen content of the total forage and appears to increase the nitrogen content of the Napier (Table 3). Similar indications have been reported by Mureithi (1992) from contemporary experiments at Mtwapa. Further monitoring of Napier/ *Clitoria* mixtures will be required to confirm these results and to assess if the survival of Napier stools relative to that in sole stands is improved.

Studies at KARI's RRC-Mtwapa and experience on smallholder farms have confirmed the palatability of *Clitoria* forage (Muinga, pers. comm.). Since 1990 the *Clitoria* has persisted in association with Napier under farmers' management at 12 sites in agro-ecological zones CL3 and CI4 in trials supervised by research and extension staff of NDDP. Since 1992 *Clitoria* seed has been distributed to some 80 smallholder farms for evaluation in farmer-managed trials organised by NDDP and the KARI/IILCA team (Thorpe et al 1993).

Macroptilium atropurpureum, Macrotyloma axillare and *Stylosanthes guianensis* were among the legumes recommended for this region by a forage germplasm screening programme carried out in the 1970's (FAO 1981). As explained by Njunie et al (this workshop) the recommendations were based mainly on a qualitative assessment without agronomic evaluation within actual production systems. Such evaluation is clearly required as demonstrated by the variable performance of the four legume species tested in this experiment. Ideally, after initial screening, agronomic evaluation and nutritive value analyses should be carried out, followed by on-farm studies to test the recommended forage technology in collaboration with farmers and the extension service.

Higher forage DM yields when Napier and *Clitoria* were cut at 10 cm above ground confirmed Goldson's (1977) concern with cutting practices. The advantage of 10 cm over 30 cm harvesting has been confirmed in the parallel experiments at this site (Mureithi 1992; ILCA 1993). More dramatic were the yield responses to mulch application in the second phase of the experiment

(Figure 2), reflecting the important influence on Napier growth and hence on DM yield of soil moisture and temperature (Larson et al 1978). Despite the high (approximately 1100 mm) mean annual rainfall at Mtwapa, its irregular distribution combined with high evaporation and the free draining soils, frequently results in extended periods of negative water balance. The mulch application may have increased soil organic matter context and reduced soil moisture loss and presumably lowered soil temperatures. Alley cropping experiments with Napier and *Leucaena* demonstrated the key relationships between soil moisture and forage productivity at this site (Mureithi 1992). Also, intercropping with *Clitoria* may have contributed plant nutrients to the soil benefitting Napier growth.

In conclusion, the experiment showed that *Clitoria ternatea* is a productive companion legume for Napier grass var Bana. *Clitoria* contributed substantially to DM production and improved the forage feeding value. The large yield responses of Napier to mulch application highlighted the critical roles of soil organic matter and moisture to sustain high forages yields. The failure of the three other legume species demonstrated the importance of evaluating forage species within the context of prevailing conditions of smallholder production systems.

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References

Batjes N.H. 1980. *A Detailed Soil Survey of the Coastal Agricultural Research Station and Farmers Training Centre, Mtwapa, Kilifi District, Kenya*. Training Project in Pedology. Agricultural University, Wageningen, the Netherlands, pp. 21.

FAO (Food and Agriculture Organization of the United Nations). 1981. Collection and evaluation of plants for animal production in Kenya, Terminal Report-AG GCP/ KEN/NOR.

Goldson J.R 1977. *Napier Grass* (Pennisetum purpureum K. Schum) in East Africa: A review. Technical Report 24. Ministry of Agriculture, Pasture Research Project. National Agricultural Research Station, Kitale, Kenya. 30 pp.

ILCA (International Livestock Centre for Africa). 1993. *Annual Programme Report 1992.* ILCA, Addis Ababa, Ethiopia.

Jaetzold R. and Schmidt H. 1983. *Farm Management Handbook of Kenya,* Volume IIC. East Kenya (Eastern and Coast Provinces). Farm Management Branch, Ministry of Agriculture, Nairobi, Kenya. 411 pp.

Larson W.E., Holt R.F. and Carlson C.W. 1978. Residues for soil conservation. In: Oschwald W.R., Stelly M., Kral M.D. and Nauseef J.H. (eds), *Crop residues management systems. ASA Special Publication* 31:1–15.

Mureithi, J.G., 1992. *Alley Cropping with* Leucaena *for Food and Forage Production in Smallholder Farms in Lowland Coastal Kenya.* PhD thesis. Department of Agriculture, University of Reading, UK.

Njunie M.N., Reynolds L., Mureithi J.G. and Thorpe W. 1995. Evaluation of Herbaceous Legume Germplasm for Coastal Lowland East Africa. AFRNET Workshop, Harare, Zimbabwe, December 1993.

Siderius W. and Muchena F.N. 1977. *Soils and Environmental Conditions of Agricultural Research Stations in Kenya.* Kenya Soil Survey. Miscellaneous Soil Paper M5. pp. 91–92.

Skerman P.J., Cameron D.G. and Riveros F. 1988. *Tropical Forage Legumes.* FAO Plant Production and Protection Series 2. FAO (Food and Agriculture Organization of the United Nations) Rome, Italy.

Thorpe W., Maloo S.H., Muinga. R.W., Mullins G., Mureithi J.G., Njunie M., Ramadhan A. and Reynolds L. 1993.Research on smallholder dairy production in coastal lowland Kenya: A collaborative programme between the Kenya Agricultural Research Institute and the International Livestock Centre for Africa. In: *Proceedings of the Workshop on The future of Livestock Industries in East and Southern Africa, held in Kadoma, Zimbabwe, 20–22 July 1992.*

Van der Valk Y. S. 1988. *Results from the Farm Survey in Kilifi District from 27th July to 27th September 1988.* Ministry of Livestock Development, National Dairy Development Project, Nairobi, Kenya.

Effets de l'association et du paillage de légumineuses herbacées sur la productivité de *Pennisetum purpureum* et sur la production fourragère totale dans la plaine côtiere du Kenya

Résumé

Clitoria ternatea, Macroptilium atropurpureum, Macrotyloma axillare et *Stylosanthes guianensis,* quatre légumineuses herbacées recommandées pour les zones à forte pluviométrie de la plaine côtière du Kenya, ont été testées pour déterminer leur potentiel d'association avec *Pennisetum* purpureum var. Bana. La pluviométrie moyenne au cours de la période d'essai était de 1180 mm/an. En mai 1989, des boutures de *P. purpureum* ont été plantées avec des espacements de 1 m sur 0,5. Environ une semaine plus tard, les légumineuses ont été semées entre ces lignes. Début septembre 1989, l'herbe a été coupée à 10 ou 30 cm au-dessus du sol alors que *P. purpureum* avait 1 m de hauteur. Six coupes ont été effectuées en 12 mois. Ni *Macrotyloma axillare* ni *Stylosanthes guianensis n'ont* surveécu à la première année d'essai. Les rendements moyens des six premières coupes de graminées légumineuses étaient de 6,4 t de MS/ha pour *C. ternatea* et 5,9 t de MS/ha pour *M. atropurpureum* avec respectivement des rendements cumulatifs de fourrage de 30 et 29,5 t/ha, chiffres qui n'étaient significativement différents, ni dans un cas, ni dans l'autre (P>0,05). Par la suite, *M. atropurpureum* n'a pratiquement survécu sur aucune parcelle, alors que *C. ternatea* a tenu bon et est resté productif.

Au cours de la seconde phase de l'essai, l'effet de l'association de *P. purpureum* et de *C. ternatea* et celui du paillage de *P. purpureum* (avec les refus, essentiellement d'herbe à éléphant) sur la production fourragère ont été comparés. Le paillage a débuté le 24 septembre 1990 et, au 24 février 1993, les neuf coupes effectuées sur les parcelles paillées ont donné un rendement cumulatif de*P. purpureum* de 42 t de MS/ha, chiffre significativement plus élevé (P<0,001) que celui de 26,1 t de MS/ha obtenu sur la parcelle temoin (sans paillage, ni culture

associée). Au niveau des parcelles de culture associée, le rendement de l'herbe à eléléphant était de 23,4 t de MS/ha contre 6,1 t de MS/ha pour *C. ternatea*, soit un total de 29,5 t de MS/ha. Le paillage a eu un effet significatif sur la persistance de l'herbe à éléphant. La hauteur de coupe n'a pas eu d'effet sur les composantes du rendement, excepté au cours de la seconde phase lorsque les rendements augmentaient avec la diminution de la hauteur de coupe ($P<0,001$).

Il ressort des réssultats obtenus que *C. ternatea* peut être recommandé pour la zone côtière du Kenya, car c'est une légumineuse persistante à rendement élevé qui s'associe bien avec l'herbe à éléphant (var. Bana). L'association a significativement augmenté le rendement total en MS de 13% et a accru le rendement en azote (et donc la valeur nutritive) d'environ 80%. Le pillage est recommandé pour maximiser la production de *P*. *purpureum*, car il accroit son rendement en MS de 60%. L'étude montre également que toute évaluation systématique des ressources génétiques fourragères doit comporter une phase d'esvaluation agronomique en système de production.

The response of three *Leucaena leucocephala* cultivars to a four-cycle cutting frequency under rainfed conditions in Zimbabwe

P. Nyathi[1]*, H.H. Dhliwayo*[1] *and B.H. Dzowela*[2]

[1]Department of Research and Specialist Services, P. O. Box 8108, Causeway, Harare, Zimbabwe
[2]Senior Scientist, International Centre for Research in Agroforestry
Box 8108, Causeway, Harare, Zimbabwe

Abstract

An experiment was conducted to investigate the relative ease of establishment and dry matter (DM) production of three *Leucaena leucocephala* cultivars (Cunningham, Hawaiian Giant and Peru) grown on a granite-derived sandy soil (pH 4.8) under an average rainfall of 600 mm/annum. Plants were first harvested at a cutting height of 50 cm above-ground after nine months of primary growth and at four monthly intervals thereafter. The cultivar Cunningham was quicker to establish than cvs Peru and Hawaiian Giant as evidenced by its high dry matter yield, nine months after establishment. Harvesting after nine months of establishment followed by repeated cutting back at four monthly intervals showed that Cunningham and Peru were susceptible to cutting stress, Peru being the most affected. Cunningham and Hawaiian Giant appeared more adaptable to repeated harvesting under a low rainfall regime than Peru.

Introduction

The concept of improving crop yields, decreasing the requirements for nitrogen fertiliser, and improving soil fertility by mixed culture of legumes and non-legumes has been an important feature in agriculture since its earliest days (Walker et al 1954). In southern Africa only a small fraction of the *Leucaena* genetic resource available is currently utilised, with planting programmes exclusively relying on *Leucaena leucocephala* (Hughes 1991). In Zimbabwe, there is a paucity of published information on the leaf quality characteristics of indigenous trees and the currently introduced exotic tree legumes (Nyathi and Campbell 1991). There was, however, an upsurge of interest in trees soon after independence of Zimbabwe in 1980 (Campbell et al 1991). Farmers have recognised the positive effects of trees on crops and in some cases reduced the use of fertilisers on crops growing under a tree canopy (Wilson 1989). This makes a strong case for the investigation of leaf quality characteristics and foliarbiomass production of trees intended for use as sources of soil nutrients for crops.

Leaf quality refers to the relative content of sugars, celluloses, hemicellulose, lignin, phenols, and the proportional content of macro- and micronutrients (Young 1987). The chemical composition of leaves has a bearing on its value as feed for livestock. Leaves of trees are also used for medicinal purposes, and as a source of plant nutrients when incorporated into the soil as green manure or added to soil as surface litter (Maghembe and Kwesiga 1991). Growth and biomass production of *L. leucocephala* has not been studied in detail in Zimbabwe. In Kenya, *L. leucocephala cvs,*Cunningham and Peru produced 60 per cent more edible dry matter per year than *Sesbania sesban* and other *L. leucocephala* cultivars (Wandera et al 1991). These workers concluded that *L. leucocephala* var Cunningham and Peru were the most suited for semi-arid environments.

One of the main advantages attributed to agroforestry is that addition of nitrogen to the system by the tree legume component, especially over time, may improve the fertility of agricultural land (Hair 1984; Huxley 1986). *L. leucocephala,* with an estimated nitrogen-fixation capability of up to 600 kg N/ha/yr (Rosenthal 1982), has the potential to be acceptable to resource-poor small-scale farmers of Zimbabwe. Research to investigate the potential of *L. leucocephala* is contribution of nutrients to the farming system whether as livestock feed or organic fertiliser has to begin with an assessment of its productivity and response to tree management manipulations.

This paper reports the results of work undertaken to compare the growth rates, leaf quality, and biomass production of three *L. leucocephala* cultivars under rainfed dryland conditions in Zimbabwe. The objectives of this study were:

- to determine leaf and stem biomass production of three *L. leucocephala* cultivars, namely, Cunningham, Hawaiian Giant and Peru in response to repeated cutting back of regrowth to 50 cm above ground
- to investigate the effects of repeated harvesting of plants on the macronutrient contents of leaves

Materials and methods

The experiment was conducted at Makoholi experiment station located at an altitude of 1200 m, with mean annual rainfall of 600 mm. Soils are granite-derived sands with a pH of 4.8 (in calcium chloride). Winter temperatures can be as low as 10°C and the mean annual temperature is 20.6°C. In some years, ground frost occurs. Seedlings were raised from hot water treated seed planted in polyethylene pockets. Two months later, in mid-December 1987, the seedlings of the three cultivars were planted in two rows each on contour bonds (1.5 m wide and 0.6 m high) at a spacing of 0.9 and 0.3 m inter- and intra-row, respectively. A compound fertiliser containing 8:14:7 (N:P:K) was applied as a basal dressing at the rate of 250 kg/ha. The fertiliser was thoroughly mixed with soil by hand-hoeing just before planting.

After nine months of primary growth, ten randomly selected plants per cultivar were cut back to 50 cm above-ground at four-monthly intervals. The cut material was stripped of leaves. Stems and leaves were weighed separately, oven-dried at 60°C for 48 hours and re-weighed for dry matter determination. Leaf samples were ground and analysed for nitrogen, phosphorus and crude fibre. All leaf analysis was carried out using methods as given in Anderson and Ingrain (1989). A two-factor (cultivars × cutting management) randomised complete block design was employed in the field layout and for statistical analysis of data. The least significant difference (LSD) test was used to establish differences between treatment means.

Results

The cultivar Cunningham was the fastest growing during the nine months of primary growth (Table 1). When cutback at the end of nine months and at four-monthly intervals thereafter, Cunningham and Hawaiian Giant grew significantly ($P<0.05$) faster than Peru by 0.33 and 0.39 cm/day, respectively.

Table 1. *Linear growth rates (cm/day) of nine months primary growth and of regrowth following four months cutting intervals.*

Cutting regime	Cunningham	Hawaiian Giant	Peru	LSD (<0.05)
9-mo primary growth	0.53	0.48	0.45	0.02
1st 4-mo regrowth	0.87	0.93	0.54	0.09
2nd 4-mo regrowth	1.32	1.34	1.11	0.11

Dry matter yields (stem, leaf or stem plus leaf) from Cunningham after nine months of primary growth were almost twice those from Hawaiian Giant and over three times those of Peru (Table 2). Repeated cutting back of regrowth resulted in non-significant ($P<0.05$) differences in DM yields obtained from Cunningham and Hawaiian Giant.

Table 2. *Mean dry matter (DM) yields (g/plant) of primary growth and regrowth following four months cutting interval.*

	Cunningham	Hawaiian Giant	Peru	LSD (<0.05)
9-mo primary growth				
Leaf	52	33	15	12
Stem	179	94	55	32
Leaf+ stem	231	127	70	49
Leaf: stem ratio	0.29	0.35	0.27	–
1st 4-months regrowth		34	20	6
Leaf	28	87	31	13
Stem	82	121	51	18
Leaf + stem	110	0.39	0.65	–
Leaf : stem ratio	0.25			
2nd 4-months regrowth				
Leaf	203	145	77	66
Stem	243	198	85	85
Leaf + stem	446	343	162	150
Leaf: stem ratio	0.83	0.73	0.91	–

These two cultivars produced almost twice the amount of leaf and stem DM obtained from Peru (Table 2). Although the leaf stem ratio improved with repeated cutting back, they were higher for Peru than for the other two cultivars, but the quantities of DM yields from Peru were very low (Table 2).

Three harvests in the first year resulted in the highest DM yields for Cunningham (Table 3). A harvest of 12 months regrowth after these frequent cuts resulted in Hawaiian Giant producing more than double and five times more DM than Cunningham and 'Peru, respectively (Table 3). This four-cycle cutting frequency improved DM yield of Hawaiian Giant relative to that of Cunningham.

Table 3. *Means of total (stems + leaves) dry matter (DM g/plant) of primary growth plus regrowth following a three-cycle cutting frequency in the first year and one cutting in the second year.*

Cutting regime	Cunningham	Hawaiian Giant	Peru	Mean	SE
Three cuts/l[st] yr	787	592	284	502	55
One cut after 12 mo	431	914	160	554	55
Mean	609	753	222	–	68

Cutting regime as shown in Table 2 significantly (P<0.05) increased crude protein content of leaves of all three cultivars (Table 4). There was a decline in crude fibre and phosphorus content of leaves with repeated cutting to 50 cm above ground (Table 4).

Table 4. *Means* of *crude protein, phosphorus and crude fibre contents of leaves* of *primary growth and regrowth obtained from plants cut at four-month intervals (% of dry matter).*

	Cunningham	Hawaiian Giant	Peru	Mean
Crude protein				
Primary growth	13.3	17.0	13.7	14.7
First regrowth	21.1	17.4.	18.7	19.7
Second regrowth	20.3	20.6	19.8	20.2
Means	18.2	18.3		
Cultivar SE	0.32	Interaction SE	0.03	
Phosphorus				
Primary growth	0.28	0.32	0.46	0.35
First regrowth	0.28	0.21	0.26	0.25
Second regrowth	0.26	0.28	0.25	0.26
Means	0.27	0.26	0.32	
Cultivar SE	0.02	Interaction SE	0.03	
Crude fibre				
Primary growth	13.8	12.7	12.1	12.8
First regrowth	13.8	13.4	13.2	12.5
Second regrowth	13.2	13.1	11.8	12.7
Means	13.6	13	12.4	
Cultivar SE	0.26	Interaction SE	0.45	

There were no significant (P>0.05) differences in crude protein content in leaves of regrowth harvested from Cunningham and Hawaiian Giant but their CP content was higher than that of Peru.

Discussion

The high DM yield obtained from primary growth of Cunningham was attributed to its establishment being faster that of the other two cultivars, possibly because of its genetic superiority over the other two cultivars. This superiority perhaps entailed effective root penetration and a proliferation of roots during establishment allowing for creation of a large rhizosphere during early growth.

A large rhizosphere developed early during establishment would enhance nutrient absorption and therefore growth. The superiority of Cunningham over Hawaiian Giant in DM production was only evident during primary growth. Following repeated harvesting after nine months of primary growth, Cunningham and Hawaiian Giant had similar growth rates and dry matter yields. This demonstrated that Cunningham was setback in its growth vigour following repeated harvesting, while Peru had low plant growth and DM yields relative to the other two cultivars. After three harvests in the first year, a further harvest of regrowth twelve months later showed that Hawaiian Giant had the best response to this cutting management (Table 3). Maarsdorp (1991) found no differences in DM yields of Peru and Cunningham when harvested only once at the end of the rains, and when grown at high altitude (1475 m) and with high rainfall (850 mm/annum) in Zimbabwe. It would appear that Cunningham and Hawaiian Giant adopt better than Peru to low rainfall (600 mm/annum) and mid-altitude (1200 m) even when repeated harvesting was tamed out soon after establishment.

A four-cycle cutting frequency improved the DM production of Hawaiian Giant owing to rapid regrowth and recovery compared to the other two cultivars (Table 3). Although the low dry mater yields observed from Peru were attributed to cutting stress, its leaf to stem ratio approached unity with repeated cutting (Table 2). An average leaf to stem ratio of 0.82 for *L. leucocephala* cultivars was reported by Maarsdorp (1991) which is an agreement with the values found in this study. Elsewhere in the semi-arid tropics, *L. leucocephala* leaf:stem ratios greater than unity have been reported (Wandera et al 1991) indicating that there is potential for increased production of leaf biomass for use either as livestock feed or as organic fertiliser during years of good rainfall.

The decline with repeated harvests in crude fibre, and the increase in crude protein of leaves for all three cultivars resulted from the growth of young succulent leaves and stems after each cut. Nitrogen was likely supplied to leaves through nitrogen fixation as evidenced by the increases in crude protein concentration with repeated harvesting of leaves of all three cultivars. The decline in phosphorus content of leaves was perhaps in part indicative of impairment of root development in response to cutting stress and to the removal of harvested material which depleted the low phosphorus reserves even further.

Conclusions

Of all the three cultivars, Cunningham was the fastest to establish as evidenced by highest DM yields following nine months of primary growth. Hawaiian Giant was the most productive following repeated harvesting showing a quicker recovery from cutting stress than the other two cultivars. Repeated cutting caused a decline in crude fibre and phosphorus content of leaves of all cultivars while crude protein content was enhanced. Cunningham and Hawaiian Giant appeared more adaptable than Peru to low rainfall and mid-altitude conditions.

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References

Anderson J.M. and Ingram J.S.I. 1989. *Tropical Soil Biology and Fertility: A Handbook of Methods.* CAB International, Wallingford, UK. 221 pp.

Campbell B.M., Clarke J.M. and Gumbo D.J. 1991. Traditional agroforestry practices in Zimbabwe. *Agroforestry Systems* 14:99–111.

Grant P.M. 1981. The fertilizers of sandy soils in peasant agriculture. *Zimbabwe Agricultural Journal* 78:169–175.

Hughes C.E. 1991. New Leucaenas for agroforestry in Southern Africa. In: Maghembe J.A., Prins H. and Brett D.A. (eds), *Agroforestry Research in the Miombo Ecological zone of Southern Africa.*Summary proceedings of an international workshop, Lilongwe, Malawi, June 16–22, 1991. p. 24.

Huxley P.A. 1986. The prediction of biological productivity and sustainability of tree–crop mixtures. *Tropical Agriculture* 63:68–70.

Maarsdorp B.V. 1991. Adaptation of the genus *Leucaena* to high altitude, sub-humid conditions in Zimbabwe. In: Maghembe J.A., Prins H. and Brett D.A. (eds), *Agroforestry Research in the Miombo Ecological Zone of Southern Africa.* Summary proceedings of an international workshop, Lilongwe, Malawi, June 16–22, 1991. p. 32.

Maghembe J.A. and Kwesiga F. 1991. Screening multipurpose trees for agro-forestry. In: Maghembe J.A., Prins H. and Brett D.A. *Agroforestry Research in the Miombo Ecological Zone of Southern Africa.* Summary proceedings of an international workshop, Lilongwe, Malawi, June 16–22, 1991. p. 23.

Nair P.K.R. 1984. Role of trees in soil productivity and conservation. In: *Soil Productivity Aspects of Agroforestry.* International Council for Research in Agroforestry (ICRAF), Nairobi, Kenya. pp. 299.

Nyathi P. and Campbell B.M. 1993. The acquisition and use of miombo litter by small-scale farmers in Masvingo, Zimbabwe. *Agroforestry Systems* 22:43–48.

Rosenthal G.A. 1982. *Plant Non-protein Amino and Imino Acids.* Academic Press, New York. 273 pp.

Walker T.W., Orchiston H.D. and Adams A.F.R. 1954. Nitrogen economy of grass–legume associations. *Journal of British Grassland Society* 9:249–274.

Wandera F.P., Dzowela B.H. and Karachi M.K. 1991. Production and nutritive value of browse species in semi-arid Kenya. *Tropical Grasslands* 25:349–355.

Wilson K.B. 1989. Trees in fields in southern Zimbabwe. *Journal of Southern African Studies* 15:36–383.

Young A. 1987*.* The potential of agroforestry for soil conservation. Part II: Maintenance of fertility. ICRAF Working Paper *43.* Nairobi, Kenya. 135 pp*.*

Performances de trois cultivars de *Leucaena leucocephala* coupés tous les quatre mois en zone Semi-aride au Zimbabwe

Résumé

Un essai a été conduit afin d'évaluer la facilité d'installation et la production de matière sèche (MS) de trois cultivars de *Leucaena leucocephala* (Cunningham, Hawaiian Giant et Peru), cultivés sur sol sableux d'origine granitique (pH 4,8) en condition de pluviométrie annuelle de 600 mm en moyenne. Les coupes étaient effectuées à une hauteur de 50 cm au-dessus du sol, la première neuf mois après l' installation, les autres tous les quatre mois. Au bout de neuf mois, le cultivar Cunningham a enregistré le rendement le plus élevé et s'est implanté plus rapidement que les deux autres. La fréquence de coupes utilisé a eu des effets néfastes sur les performances des cultivars Cunningham et Peru, ce dernier ayant été le plus affecté Les cultivars Cunningham et Hawaiian Giant semblent mieux adaptés que le cultivar Peru à un régime de coupes répétées daps des conditions de faible pluviométrie.

Research on the integration of forage legumes in wheat-based cropping systems in Ethiopia: A review

Daniel Keftasa

Debre Zeit Agricultural Research Centre, Alemaya University of Agriculture
P. O. Box 32, Debre Zeit, Ethiopia

Abstract

There are important linkages between livestock and wheat production in the mixed farming systems of Ethiopia. These linkages are strengthened by the use of straw as livestock feed, and by the potential to produce leguminous forages that can simultaneously address livestock dietary constraints caused by low feed quality during the dry season and constraints to wheat production caused by declining soil fertility. Field studies have been carried out to assess the effects of different forage legumes on the yield of wheat, through intercropping/undersowing or rotations at selected sites in the major wheat growing zones of Ethiopia. These studies suggest that annual forage legumes of the genera of *Trifolium* and *Vicia* and multipurpose tree legumes such as *Sesbania* and *Chamaecytisus*species can be incorporated into predominantly wheat-based farming systems to maintain wheat yields and to improve the quality of crop residues as livestock feed.

Introduction

In Ethiopia, about 80% of the 27 million cattle, 88% of the 53 million human population, and 95% of the regularly cropped land are found in the high-potential agricultural areas (> 1500 m altitude and >700 mm rainfall) which cover 43% of the land area. This indicates high human and livestock population densities. The predominant type of agriculture is smallholder mixed crop/livestock farming with land holdings ranging from 0.5 to 4.0 ha (Gryseels and Anderson 1983). Cropping and livestock production have been closely integrated and complementary; oxen are used for cultivation and crop residues play a crucial role in livestock nutrition. It is estimated that crop residues and post-harvest grazing contribute 10–50% of the annual feed demand in the highlands (Keftesa, 1988). Wheat is a major cereal crop covering about 10% of the cropped land producing about 1 million tons of crop residues or 8.3% of available total (Said and Adugna Tolera 1991).

Natural pastures have been the main livestock feed source but grazing lands are gradually being brought into cultivation to satisfy the needs of the increasing human population. At the same time crop yields are falling due to increased cropping pressure causing shorter fallow periods. Concentration of livestock on the shrinking grazing lands caused overstocking leading to soil degradation, which in turn has resulted in a decline in livestock productivity. To improve crop productivity and at the same time increase feed output, efforts are being made to introduce high yielding forage species into existing cropping systems. However, the land and labour requirements of sown forages has limited wide adoption. Therefore, forage research on the integration of forages, particularly legumes, into wheat cropping in the medium-altitude highland zones of Ethiopia has become a major focus. This paper reviews several studies on intercropping forages and wheat, forage and wheat rotations and improvement of the residue quality to increase livestock feed output.

Intercropping/undersowing

Intercropping of wheat with legume forages is a means to maintain soil fertility during the cropping phase. This system would reduce the competition for land because the same land is simultaneously used for both crop and forage production. Research has shown that different species of forage grasses can be successfully established under wheat without reducing grain yield as shown in an experiment on the reddish clay soils at Holetta: undersowing forage improved wheat yield by 36%, straw yield by 21 % and availability of total feed by 65% over and above the sole wheat crop (Table 1).

Table 1. *Comparison of grain and herbage yield of wheat alone and with forages in Holetta.*[1]

	kg DM/ha			
Treatment	Grain kg/ha	Straw	Forage	Total
Wheat alone	2040	7900	–	7900
Wheat + grasses	2780	9580	3470	13050

1 Summarised from Lulseged and Jemal (1989).

On black clay soils at Ginchi it was observed that grain yield of wheat was reduced by about 20% when undersown with forage grasses but no diminishing effect was observed with forage legumes (Table 2).

Table 2. *Wheat grain yield and forage establishment on black clay soil at Ginchi.*

Treatment	Wheat (kg/ha)	Forage (kg/ha)
Wheat alone	2930	–
Wheat + legumes	2930	2000
Wheat + grasses	2344	1000

Source: Lulseged and Jemal (1989).

Abate Tedla and Jutzi (1985) reported that undersowing native clovers, namely *Trifolium tembense* and *T*. *rueppellianum,* significantly improved both wheat grain and residue total yield by 22 and 29%, respectively. The ideal legumes for intercropping would need the ability to compete with the companion wheat crop and to withstand shading. Late maturation would be important as the wheat would need to be harvested first. Wheat varieties maturing in about 100–120 days would be ideal. Late-maturing types of *T*. *decorum,* on Nitosols and *T*. *tembense* and *T*. *quartinianum,* on heavy Vertisols, would be suitable for intercropping with early-maturing varieties of wheat. It is often observed that the native clovers grow naturally in crops and farmers leave them for grazing by livestock after grain harvest.

Forage legume–wheat rotation

Introducing forage legumes into existing cropping systems at medium altitudes, where wheat is intensively cultivated, would provide the opportunity to substitute fallowing of fields and fallow grazing as livestock feed source. Forage legumes would accelerate the fertility re-building phase and at the same time provide a high quality forage source for use during the dry season.

Wheat yield can be improved by between 55 and 128 per cent without fertilisers and by 35 to 65 per cent with fertiliser by incorporating vetch or vetch/oat mixtures in the rotation.

This is comparable or slightly higher than the rotation with horsebeans, the common rotation crop in the region (Table 3). From such a system forage yield of 6 tons (20% CP) from vetch and vetch/oat mixtures 8 tons (13% CP) can be obtained.

Table 3. *Effect of fallow, horsebean, vetch and oat/vetch mixture on the subsequent wheat crop at nil and 100 kg/ha DAP.*

	Wheat yield (kg/ha)	
Pre-treatment	0	100 kg DAP
Wheat	1450	3400
Fallow	1800	2400
Horsebean	2250	3000
Vetch	2250	3100
Oats/vetch	3300	3800

1 DAP = Di-ammonium phosphate (18% N + 46% P_2O_5). Source: Unpublished data, ARDU, Kulumsa.

Analysis of wheat grain yield from two long-term rotation experiments in the Arsi region indicates that oat/vetch mixture improved wheat yield significantly compared to a wheat monoculture (Table 4). At Kulumsa (clay loam soil) wheat following oat/vetch produced 40 and 25 per cent more grain yield in 1 year and 2-year rotational systems, respectively, as compared to wheat monoculture. At Robe (Vertisol) yields increased by 108 and 16 per cent in 1-and 2-year rotational systems, respectively.

Table 4. *Average grain yield of wheat as affected by crop rotation at two sites in Arsi Province, Ethiopia.*

							Grain yield (kg/ha)	
Treatment	1984	1985	1986	1987	1988	1989	Kulumsa	Robe
1	Fb	W	*O/V*	*W*	*	W	2840[ab]	2095[abc]
2	O/V	W	*	W	Fb	W	3179[a]	2686[a]
3	*	W	Fb	W	O/V	W	2545[bc]	2614[ab]
4	Fb	W	W	O/V	W	W	2270[d]	1451[bc]
5	O/V	W	W	*	W	W	1992[d]	1202[c]
6	*	W	W	Fb	W	W	2541[bc]	1360[c]
7	W	W	W	W	W	W	1813[d]	1255[c]
Mean							2454	1827

LSD(0.01)	504	1164

O/V = oat/vetch forage mixture; W = wheat; Fb = faba (horse) bean.

* = rapeseed at Kulumsa and noug at Robe.

Figures followed by the same letter are not significantly different at the 1% level.

Source: Tanner et al (1991)

Wheat residues

Wheat straw is one of the most important cereal straws in medium-highland zones of Ethiopia. It is utilised as livestock feed either as stubble grazing or is collected and stall-fed mostly during the dry season. Residues from improved varieties of wheat amounted to about 6 tons with residue to grain ratios ranging from 1.8 to 2.9 (Daniel Keftasa 1988). Wheat residue is characterised by low metabolisable energy content (<7.0 MJ/kg DM), low crude protein content (<50 g/kg DM), and low content of minerals but is high in cellulose, lignin and silica, resulting in low voluntary intake. A comparison of yield and nutritional value of major cereal crops in Ethiopian highlands shows that wheat residue is generally lower in protein and metabolisable energy contents than barley and tef*(Eragrostis* tef) (Table 5).

Table 5. *Mean yield and nutritional values of straw of improved varieties of wheat, barley and tef in Arsi region, Ethiopia.*

	Yield (kg/ha)		Nutrients (g/kg DM)			Metabolisable energy MJ/kg DM
	Grain	Residue	DCP	Ca	P	
Wheat	3900	5570	4	2.4	0.7	62
Barley	2705	5750	18	3.0	0.8	6.8
Teff	2100	7030	19	4.1	0.5	6.8

Source: Daniel Keftasa (1988).

In a comparative study to assess the performance of steers fed on different cereal residue-based diets, a daily weight gain of 352 g was recorded on a ration containing 50% wheat residue, 20% molasses, 25% noug cake (*Guizotia abyssinica*), 4% bone meal and 1 salt. This is about 45 and 20 per cent below the gains observed on tef and oat residues-based rations, respectively (Mosi 1981). These and similar studies suggest that wheat residue is a poor roughage which requires supplementation for better livestock performance. One study showed that incorporation of clovers into wheat by undersowing improved crude protein content (7.1% vs 2.3%) and *in vitro* organic matter digestibility by 17 per cent as compared to wheat straw alone (Tekalign et al 1993). The effect of date of undersowing vetch (*Vicia dasycarpa*) on grain and straw yields of wheat was studied at Kulumsa (ARDU 1980). Wheat grain yield was significantly affected by the presence of the legume when planted at the same time; but legume and residue yield together were significantly higher than the control (Table 6). Grain yield of wheat and vetch yield was related: the DM yields of vetch showed a decreasing linear trend as its planting time was delayed. Beyond the 4th week of planting, wheat grain yield was not significantly affected but the yields of straw and vetch together were higher than that of wheat alone. This suggests that if wheat and vetch are to be planted on the same field the vetch should be undersown after the wheat crop has been fully established.

Table 6. *Effect of date of undersowing vetch on grain and straw yields of wheat and dry matter yield of vetch, Kulumsa, Ethiopia.*

Treatment	Planting date of vetch after wheat (wks)	Yields DM (kg/ha			
		Grain	Straws	Vetch	Total feed
Wheat alone	–	2370[b]	3208[b]	–	3208
Wheat + vetch	0	991[a]	2000[a]	7200[d]	9200
Wheat +vetch	2	2355[b]	2500[b]	3542[c]	6042
Wheat + vetch	4	2595[bc]	2300[a]	1875[b]	4175
Wheat + vetch	6	3070[c]	3000[ab]	1000[a]	4000
Wheat +vetch	8	3070[c]	3157[b]		3957

Figures in column followed by the same letter are not different at (5% level).

1 Stubble after cutting by hand at about 40 cm height.

Source: ARDU (1980).

Adding forage legumes to wheat straws is a practical means of improving feed intake and weight gain. Butterworth and Mosi (1986) reported that supplementing wheat straw with *Trifolium* hay at about 50% of total feed increased dry matter digestibility from 40% to 53%. In another study Olayiwole et al (1986) reported a rise in dry matter intake by 4 g/kg LW $^{0.75}$ and weight gain of 227 g/day when *Trifolium* is added to wheat straws compared 113 g/day without *Trifolium*.

Discussion

Several suitable forages legumes are available in the wheat growing regions of Ethiopia for potential intercropping, alley cropping, rotation or supplementation to wheat residues. Among these, native*Trifolium* species, vetch and/or vetch/oat mixtures and multipurpose trees could fit well into existing production systems.

The introduction of these leguminous fodders into small-scale mixed farming systems would improve soil fertility, crop yield, roughage quality and make the system more sustainable. Growing multipurpose trees such as sesbania *(Sesbania sesban)* and Tagasaste *(Chamaecytisus palmensis)* in alley cropping, particularly on terraces as a soil conservation strategy, and use the foliage as a supplement to wheat residues. The current trend in Ethiopia is towards a wider utilisation of multipurpose trees in mixed crop–livestock production systems because they can provide high quality fodder for livestock, improve soil fertility, conserve moisture and satisfy other needs such as fuelwood, building material, shade and shelter. The livestock in mixed farming systems stabilises food production by buffering the fluctuations in crop yield across seasons while forage legumes can contribute to sustain the system through soil fertility maintenance, soil conservation and to improve the quality of residues for livestock feed.

References

Abate Tedla and Jutzi S. 1985. *Results of Cereal Forage Legume Intercropping Trial on Small holder Farms in the Ethiopian Highlands.* Highlands Program Report. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

ARDU. 1980. *Report on Trials and Observations Carried Out in 1976–78 on Forage and Pasture Crops Agronomy.* Crop Pasture Section, Asella. ARDU Publication 16.

Butterworth M.H. and Mosi A.K. 1986. The voluntary intake and digestibility of combinations of cereal crop residues and legume hay for sheep. *ILCA Bulletin* 24:114–117.

Daniel Keftasa. 1988. Role of crop residues as livestock feed in Ethiopian highlands. In: Dzowela B.H. (ed), *African Forage Plant Genetic Resources, Evaluation of Forage Germplasm and Extensive Livestock Production Systems. Proceedings of workshop held at Arusha, Tanzania, 27–30 April, 1987.* ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Gryseels G. and Anderson F.M. 1983. *Research on Farm and Livestock Productivity in the Central Ethiopian Highlands. Initial Results 1977–1980.* ILCA Research Report 4. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Lulseged Gebrehiwot and Jemmal Mohammed. 1989. The potential of crop residues, particularly wheat straw, as livestock feed in Ethiopia. In: Said AN and Dzowela B.H. (eds), *Overcoming Constraints to the Efficient Utilization of Agricultural By-products as Animal Feed.* African Research Network for Agricultural By-products (ARNAB), ILCA, Addis Ababa, Ethiopia. pp.142–154.

Mosi A.K. 1981. The role of tef straw *(Eragrostis tef)* as livestock feed in the Ethiopian highlands. In: Kategile A.J., Said A.N. and Sundstol F. (eds), *Utilization of Low Quality Roughages in Africa. Norway:* Aas, Norway.

Olayiwole M., Butterworth M.H., Sayers A.R. and Olorunju S.A.S. 1986. The effect of supplementing cereal straws with urea, *Trifolium* hay and noug meal on feed intake and liveweight of growing crossbred heifers. *ILCA Bulletin* 24:18–19.

Said A.N. and Adugna Tolera.1991. Utilization of wheat straw in Ethiopia. In: Hailu Gebre-Mariam, Tanner D.G. and Mengistu Hulluka (eds), *Wheat Research in Ethiopia. A Historical Perspective.*IAR/CIMMYT (Institute of Agricultural Research/Centro Internacional de Mejoramiento de Maiz Y Trigo), Addis Ababa, Ethiopia.

Tanner D.G., Amanuel Gorfu and Kassahun Zewde. 1991. Wheat agronomy research in Ethiopia. In: Hailu Gebre-Mariam, Tanner D.G. and Mengistu Hulluka (eds), *Wheat Research in Ethiopia. A Historical perspective.* IAR/CIMMYT (Institute of Agricultural Research/Centro Internacional de Mejoramiento de Maiz Y Trigo), Addis Ababa, Ethiopia.

Tekalign M., Abate T. and Teklu E. 1993. *The effect of Undersowing Wheat with Clovers on Wheat Grain Yield, Total Crop Residue and Nutritional Value of Straw and Fodder Grown on Vertisol in Ethiopia.* Paper presented at the 8th Regional Wheat Workshop for Eastern, Central and Southern Africa, June 7–10, 1993, Kampala, Uganda.

Recherches sur l'intégration des légumineuses fourragères daps les systèmes agricoles à base de blé en Ethiopie: revue de la literature

Résumé

Il existe des liens étroits entre l'élevage et la production de blé dens les systèmes de production mixte en Ethiopie. Ces liens sont renforcés par l'utilisation de la paille de blé comme aliment du bétail et par la possibilité de cultiver des légumineuses fourragères, lesquelles peuvent permettre de faire face simultanément non seulement aux problèmes alimentaires du bétail resultant de la qualité médiocre du fourrage au cours de la saison sèche, mais également à ceux de la production du blé par l'amélioration de la fertilité des sols. Des études en milieu réel ont été menées pour évaluer l'effet de la culture de différentes légumineuses fourragères sur le rendement du blé, par le biais de cultures associées, de semis sous-culture ou de rotations sur certains sites dens les principales zones de production de blé en Ethiopie.Il ressort des résultats de ces travaux que les légumineuses fourragères des genres *Trifolium et Vicia*, ainsi que les légumineuses ligneuses à usages multiples comme *Sesbania et Chamaecytisus* peuvent être incorporées aux systèmes agricoles essentiellement à base de blé pour maintenir les rendements de cette céréale et améliorer la qualité des résidus de récoltes comme aliments du bétail.

The effect of staking on seed yield and quality characteristics of *Macroptilium atropurpureum* at Namulonge, Uganda

P. Lusembo[1], EN. Sabiiti[2] and JS. Mugerwa[2]

[1]Namulonge Agricultural and Animal Research Institute,
P. O. Box 7084, Kampala
[2]Crop Science Department, Makerere University,
P. O. Box 7062, Kampala, Uganda

Abstract

Studies were conducted to determine the effect of staking *Macroptilium atropurpureum* cv Siratro on yield and quality of seed. Results showed that there was a positive correlation (r^2=0.97) between staking height and seed yield. Weight of 100 seeds was improved by staking ($P<0.05$) over no staking, but there was no difference among the various staking heights. There was a positive correlation between seed size and germination rate: thus, staking improved both seed yield and quality.

Introduction

Sustained production of high quality feed from forage crops often requires regular supplies of high quality seed. Such seed should be locally produced as sustained pasture development can not depend on imported seed (Loch 1987). Siratro is an important forage legume that is recommended for pasture improvement in Uganda. Low seed yields and poor germination of harvested seed have limited the use of this legume. Provision of support to climbing forage legumes is known to increase seed yield (Ferguson 1978; Humphreys and Riveros 1986). But there is scarce information on how support systems affect the quality of seed. The percentage of seed germinating under laboratory conditions has been the standard measure of seed quality (ISTA 1976). However, the vigour of the seed and the rate of germination are other important measures of seed quality (Chin and Wong 1993). Seed lots may have the same germination percentage but may germinate at different rates (Dourado 1985). A seed that germinates fast will ensure early establishment and seedlings would avoid subsequent adverse conditions like moisture stress and competition from fast germinating weeds. Providing climbing plants support from stakes increased seed yield and its components (Lusembo et al 1993). Some seed yield components, like seed size may have a direct bearing on seed quality. Positive correlations between seed size, germination percent and germination rate have been found (Dourado 1989). Therefore, agronomic practices that increase seed size may improve the overall seed quality. Germination of seed is usually determined according to the procedure laid down by the International Seed Testing Association (ISTA 1976). The germination rate is calculated according to the formula proposed by Maguire (1962):

Rate of germination = X1 /Y1 + (X2 – X1)/Y2 + (Xn – Xn l)/Yn

Where, Xn =percentage seedling emergency at n^{th} count and Yn = number of counts from planting to n^{th} count

This paper reports on whether there was any correlation between staking height with seed yield and seed quality characteristics of Siratro, and whether there was any association between seed yield and seed quality.

Materials and methods

The study was carried out at the Namulonge Agriculture and Animal Research Institute (0°32'N and 32°35'E) in the subhumid zone of Uganda. The experimental site had been under natural fallow for five years; it was disc-harrowed into a fine seedbed and single superphosphate at a rate of 250 kg/ha was applied. The area was demarcated into plots (3×3 m) separated by one metre borders. Siratro was planted at a spacing of 1×1 m. The treatments were staking heights of one, two and three metres which were assigned to plots in a completely randomized block design with four replications. Dry stakes of locally available bamboo *(Arundiharia alpina)* were fixed at 30 cm distance from each plant. The control treatment was not staked.

Insect pests were controlled by fortnightly applications of Ambush CY (1 1/ha). The crop was kept weed-free by hand-weeding. Mature purple and dry pods were harvested at intervals of one week for two growing seasons. Harvested pods were sun-dried before threshing. Four samples of 100 seeds were counted from each bulk sample and weighed. A germination test was carried out on four batches of 100 seeds each.

Each sample of seed was immersed in sulphuric acid for 20 minutes to break hardseededness. The seeds were then washed with water and left to germinate on moist filter paper placed in petri dishes at room temperature (ISTA 1976). Seed was considered germinated when the plumule emerged. Seedlings were counted daily from the third to the seventh day. The germination rate was determined according to the formula suggested by Maguire (1962). Germination was taken on the seventh day by counting the total number of seeds with emerged plumules.

Results and discussion

The weight of 100 seeds of staked plants increased as compared to unstaked ones. This was ascribed to the induction of erectophilic tendencies by provision of a support system to an otherwise planophilic species, allowing the accumulation of assimilates in the supported crop, thereby increasing seed size. However, there was no significant (P>0.05) difference in 100-seed weight among the various staking heights (Table 1).

Table 1. *The effect of staking height on the weight of 100 seeds, germination rate and germination percentage of* Macroptilium atropurpureum cv *Siratro.*

	Staking height (m)				
	0	1	2	3	SEM
100-seed weight	1.3a	1.4b	1.4b	1.4b	0.1
Germination rate	18.0a	20.0b	21.0b	21.0b	0.6
Germination %	81.0a	90.0b	92.0b	90.0b	3.0

Means in the same row with different superscripts are significantly (P<0.05) different.

There was a significant (P<0.01) and positive correlation (r^2 = 0.97) between staking height and total seed yield/plant This may have been due to an increase in the number of seeds per plant in relation to staking height or may have been caused by an increasing leaf surface area with staking height. This agrees with the findings in Nigeria by Akinola and Agishi (1989). A germination test indicated that staking increased (P<0.05) the rate and overall germination percentage of seed germination (Table 1). It was concluded, therefore, that staking increases both seed yield and quality which may be attributed to the relatively larger seed size (Dourado 1989).

References

Akinola J.O. and Agishi E.C. 1989. Seed production and forage performance of Centro *(Centrosema pubescens)* and Siratro *(Macroptilium atropurpureum* cv Siratro) as influenced by staking and type of pod harvest. *Tropical Grasslands* 23:225–231.

Chin and H.F. and Wong C.C. 1993. The importance of tropical pasture seed quality and factors affecting it in smallholder farming systems. In: *Eighteenth International Grassland Congress, Palmerston North, New Zealand, 8–21 February 1993* (in press).

Dourado A.M. 1989. The effect of seed size, method of accelerated ageing on germination of 'grasslands Matua' prairie grass *(Bromus catharticus). Seed Science and Technology* 17:283–288.

Ferguson J.E. 1978. Systems of pasture seed production in Latin America. In: Sanchez P.A. and Tergas L.E. (eds), *Pasture Production in Acid Soils* of *the Tropics.* CIAT (Centro Internacional de Agricultura Tropicale), Cali, Colombia. pp. 413–426.

Humphreys L.R. and Riveros F. 1986. *Tropical Pasture Seed Production.* FAO Plant Protection and Production Paper 8. FAO (Food and Agriculture Organization of the United Nations), Rome, Italy. 203 pp.

ISTA. 1976. International rules for seed testing. *Seed Science and Technology* 4:23–28.

Loch D.S. 1985. Commercial seed increase of new pasture cultivars: Organization and Practice. In: Kategile J.A. (ed), *Pasture Improvement Research in Eastern and Southern Africa.* IDRC-273e. Proceedings of a workshop held at Harare, Zimbabwe, 17–21 September 1984. IDRC (International Development Research Centre), Ottawa, Canada. pp. 392–424.

Lusembo P., Sabiiti E.N. and Ebong C.E. 1989. The use of different support systems for the seed production of Centro. In: *Eighteenth International Grassland Congress, Palmerston North, New Zealand;* 8–21 *February* 1993 (in press).

Maguire J.D. 1962. Speed of germination-aid in selection and evaluation for seed emergency and vigour. *Crop Science* 2:176–177.

Effet de l'utilisation de tuteurs sur le rendement et la qualité des semences de *Macroptilium atropurpureum* à Namulongue (Ouganda)

Résumé

Des études ont été menées pour déterminer l'effet de l'utilisation de tuteurs sur le rendement et la qualité des semences de *Macroptilium atropurpureum* cv. Siratro. Les résultats obtenus indiquent qu'il existe une corrélation positive (r^2 = 0,97) entre la hauteur du tuteur et le rendement en semences. Le poids de 100 graines a été amélioré ($P<0,05$) par l'utilisation de tuteurs. Toutefois, on n'a pas enregistré de différence entre les diverses hauteurs de tuteurs utilisées. En outre, une corrélation positive a été mise en évidence entre la taille des semences et leur taux de germination, ce qui permet de conclure que l'utilisation de tuteurs améliore aussi bien le rendement que la qualité des semences.

Pasture seed production of promising grasses and legumes at Domboshawa, Zimbabwe

J.F Mupangwa

Agritex, P.O.Box 8117, Causeway, Harare, Zimbabwe

Abstract

Pasture seed in Zimbabwe is scarce and if available, its cost is high making seeds unaffordable for the majority of smallholder farmers. This project aims at pasture seed bulking of legumes and grasses for issue to smallholder farmers for on-farm feed production for various livestock enterprises.

Based on best-bet recommendations from screening trials in research stations, thirty grass species and twenty seven legume species were selected for seed bulking. However, due to the poor rains in 1990/91 and a severe drought in 1991/92, almost all sowings failed and results were obtained mainly during the good 1992/93 season. The best four seed-producing legumes were *Cajanus cajan*(800 kg/ha), *Lablab purpureus* (750 kg/ha), *Macrotyloma axillare* (200 kg/ha) and *Cassia rotundifolia* (300 kg/ha). Seed yields of successful grasses were *Panicum coloratum* (200 kg/ha), *P. maximum*(500 kg/ha) and *Digitaria milanjiana* (300 kg/ha). Seeds were issued to small-scale farmers, who were encouraged to harvest seed from their initial plots so as to expand their forage output.

Introduction

In Zimbabwe, little research has been done on seed production and instead concentrated on pasture evaluation, species screening and herbage production under various systems; e.g. rain-fed versus irrigated and fertilised vs unfertilised forage production. The only seed production project was on Silverleaf *Desmodium* (Irvine 1984). Despite the merits of some of the evaluated forage species, they have not been distributed to small holder farmers, largely because of lack of seed.

Livestock production in Zimbabwe relies on natural grazing as the main source of feed. However, natural pastures fluctuate greatly in nutritive value; for instance, crude protein values may drop from 12% in the rainy to as low as 2% in the dry season. Thus, there is loss of livestock condition in the dry season, which is greater in the smallholder sector than on commercial ranches mainly because of inadequate grazing and lack of planted forages in smallholder enterprises. For sustainable livestock production in this sector there is a need to introduce both forage legumes and grasses which can be used as supplementary feed in the dry season. However, this is difficult to achieve without sufficient pasture seed of well adapted species. This project aimed at increasing pasture seed production to supply to small holder farmers.

Materials and methods

Site description

The pasture seed multiplication centre is located in a government farm at Domboshawa, 35 km north-east of Harare. The farm receives an annual rainfall of 850 to 900 mm. Most of the rain falls between December and April in unimodal fashion. Little rain is received during the dry season. Mean summer and winter temperatures are 22°C and 15°C, respectively, and frost occurs occasionally, especially during May and June. The soils are mainly sands and sandy loams derived from granite, are well drained with a pH of 6.3, but with a low phosphorus content.

Pasture species established

The species of pasture grasses and legumes selected to produce seed were best-bet material from evaluation trials conducted at research stations at Henderson and Grasslands. Grass species included: *Panicum coloratum* cv Bambatsii, *P. maximum* cv Gatton, *Setaria sphacelata* cv Kazungula and *Digitaria milanjiana.* Bajra, a commonly grown Napier hybrid a cross of Napier *(Pennisetum purpureum)* and bullrush millet (*P*. *typhoides* – *was* also established. Legumes included: *Lablab purpureus* cvs Rongai, Ghansi and Highworth, *Cajanus cajan, Macrotyloma axillare* cv Archer,*Macroptilium atropurpureum* cv Siratro and *Cassia rotundifolia* cv Wynn.

Establishment

The initial seed were received from the ILCA genebank. The plot was ploughed by tractor in October 1990, while single superphosphate (SSP) fertiliser at a rate of 200 kg/ha was broadcast and disced into the soil. After the first effective rains, rows 45 cm apart were marked using an ox-drawn tropicultor. A seeding rate of 3 kg/ha for grasses and 4 kg/ha for legumes were used (Skerman et al 1988). Small seeds were drilled along the row whilst for *Cajanus cajan* seed was planted at 0.45 m spacing within the row.

The legume seeds were inoculated with relevant rhizobia in a sugar solution before sowing.

Germination in 1990/91 and 1991/92 rainy seasons was low for most species and seedling growth was poor. As all crops died during the 1991/92 drought, all species were planted again in 1992/93. Most plots showed good germination (85%) and were hand-weeded.

Seed harvesting

All seeds were harvested by hand. For grasses the timing of ripeness and method of harvesting may affect yield and quality of harvested seed. Ripeness of the seed was judged by ease of seed removal from the inflorescence as a criterion. Ripe inflorescences were cut with small knives. The seed heads were heaped in the shade and covered with plastic sheeting for three days. This process called sweating assists in loosening mature seed from the seed heads (Hopkinson 1992). After sweating the seed heads were lightly threshed and seed collected, which was further dried and stored. Bajra grass plants were left to maturity and cuttings were made for planting during the 1993/94 rainy season. For some of the legumes, ripe pods were hand picked and dried in a shade before seed was extracted by hand-peeling of the pods. For *C*. *rotundifolia,* Siratro and Archer the pods were lightly threshed and winnowed to separate seed from trash.

Results

The average seed yield for *C. cajan* was equivalent to 800 kg/ha and for *Lablab purpureus* 750 kg/ha. These yields are comparable to those reported by Skerman et al (1988). Grass seed yields were as follows: *Panicum coloratum* 200 kg/ha, *P. maximum* 500 kg/ha, *Digitaria milanjiana* 300 kg/ha. *Setaria* did not establish well, hence no seed was harvested. The actual quantities of seed harvested are shown in Table 1. Hardly any seed was obtained in the 1990/91 and 1991/92 rainy seasons because of drought.

Table 1. *Quantities of seed collected at Domboshawa Government Farm.*

Legumes	Yield (kg)
Cajanus cajan	20
Lablab purpureus	23
Macrotyloma axillare	*5*
Cassia rotundifolia	6
Grasses	
Panicum maximum	13
P. coloratum	6
Digitaria milanjiana	36

Conclusions

Since seed yields were comparable to those reported in the literature when rains were satisfactory, the project will be expanded during the coming season. Farmers who received seed from the project will be encouraged to produce their own seed so as to expand their forage plots.

References

Hopkinson J.M. 1992. Harvesting legume and grass seed. In: International Training Course – Tropical Pasture Seed Production, Course Manual Patridge I.J. (ed). Irvine A.D. *1984. Management of the Sub-tropical Pasture Legume,* Desmodium Uncinatum (Jacq. D.C.), *Grown for Seed Production in Zimbabwe.* Thesis paper. University of Zimbabwe.

Skerman P.J., Cameroon D.G. and Riveros F. *1988. Tropical Forage Legumes.* Second edition 1. FAO.

Production de semences fourragères de graminées et de légumineuses prometteuses à Domboshawa (Zimbabwe)

Résumé

Au Zimbabwe, les semences fourragères sont rares et lorsqu'elles sont disponibles, elles sont trop chères pour la plupart des petits exploitants agricoles. L'objectif du présent projet est donc la production en masse de semences de légumineuses et de graminées en vue de leur distribution aux petits exploitants pour la production d'aliments du bétail adaptés aux diverses conditions d'élevage.

Sur la base des espèces les plus prometteuses recommandées à la suite d'essais de sélection effectués en station, 30 espèces de graminèes et 27 espèces de légumineuses ont été retenues pour une production massive de semences. Toutefois, en raison des maigres pluies de 1990–1991 et de la sécheresse de 1991–1992, les semis n'ont pratiquement rien donné ces années et des résultats n'ont pu être pu etre obtenus que lors de la bonne saison 1992–1993. Les quatre légumineuses ayant donné les meilleurs rendements en semences étaient *Cajanus cajan* (800 kg/ha), *Lablab purpureus* (750 kg/ha), *Macrotyloma axillare* (200 kg/ha) et *Cassia rotundifolia* (300 kg/ha). Chez les graminées, les meilleurs rendements ont été enregistrés par *Panicum coloratum* (200 kg/ha),*Panicum maximum* (500 kg/ha) et *Digitaria milanjiana* (300 kg/ha). Des semences ont été distribuées à des petits exploitants à qui il a été recommandé de produire leurs propres semences en vue d'accroître leur production de fourrage.

Feed Evaluation: Nutritive Value and Animal Intake

Assessment of forage legumes as protein-rich supplement in ruminant production systems in Zimbabwe

J. H. Topps

Department of Animal Science, University of Zimbabwe
P.O Box. MP 167, Harare, Zimbabwe

Abstract

A screening system is proposed to assess the nutritive value of shrubby and herbaceous legumes as supplements to low to medium quality roughage diets in different livestock production systems in Zimbabwe. Plant material was obtained in February 1992 (i.e. rainy season) from research centres in and around Harare. Only the leaf fraction was analysed.

Ranges of values of up to 20 legume species are given for crude protein content (20); acid detergent insoluble nitrogen (13); rumen degradability (14); ash content (20); neutral and acid detergent fibre (14); acid detergent lignin (14) and anti-nutritional factors (condensed tannin, lectin). The suitability of the 20 legumes studied differed appreciably. This set of characteristics based on laboratory analyses should be followed by acceptability trials using animals. This scheme of assessment may provide a means of selecting the most appropriate legumes for further examination, which can then be further tested in production and field trials.

Introduction

Forage legumes have become increasingly important in Zimbabwe as protein-rich forages to supplement a basal diet of either grass or poor quality roughage for ruminant livestock. For smallholder milk production in particular, legumes are needed to provide a balanced diet when grown on the same farm as a grass forage such as Napier fodder (cv bana grass), to sustain lactation yields of 2000 litres. In recent years a large number of species of either herbage or shrub legumes have been established successfully in Zimbabwe and there is a need to assess their suitability for ruminant production systems especially with respect to the efficient utilisation of dietary protein. This paper describes a scheme that may be appropriate for such an assessment and gives results for 20 different species, seven of which are herbage legumes and 13 of which are shrub legumes.

Materials and methods

The examined plant material was obtained in February 1992 from plots of herbage legumes grown at the Department of Crop Science, University of Zimbabwe, Harare and from plots of shrub legumes grown at Domboshawa approximately 35 km north of Harare. Normally, the monthly rainfall for February is among the heaviest for the year, but in 1992 a severe drought affected southern Africa and virtually no rain had fallen during the summer months when most of the annual rainfall is precipitated. The herbage legumes but not the shrub legumes had received supplementary irrigation. Herbage legumes were cut at different heights above the ground according to their growth habits, dried at 60°C and milled through a one mm screen. Shrub legumes were harvested to remove leaf and twig material but in a way compatible with encouraging re-growth and subsequent harvesting. The material was separated into leaf and stem, dried at 60°C and milled through a one-mm screen. The leaf samples only were used in this investigation.

The methodology applied to assess the different species as protein-rich supplements was the determination of chemical composition, the measurement of certain anti-nutritional factors and assessment of rumen degradability of protein. Chemical composition was determined according to Association of Official Analytical Chemists (AOAC 1984), anti-nutritional factors such as condensed tannins and lectins were measured by the methods of Butler, Price and Brotherton (1982) and the dilution technique described by Hare (1992), respectively, and rumen degradability of protein was assessed by following the procedure of Orskov et al (1980).

Results and discussion

Crude protein determination

The most relevant and basic determination for protein-rich forages is that to measure the crude protein (CP) content. If the forages are used to supplement low quality roughages with a CP content of 30 g/kg DM or less at a level of no more than 25% of total dietary dry matter, the forage should contain 230 g CP/kg DM or more to ensure that the diet contains a minimum of 80 g CP/kg DM. Similar calculations for a forage based diet to support milk production with the grass forage containing 80 g CP/kg DM and a desirable level in the final diet of 100 g CP/kg DM, shows that the legume forage should contain 160 g CP/kg DM. Summary results for 20 species are shown in Table 1.

Table 1. *Crude protein content (g/kg DM) of 20 legume species.*

Range	1099–292
Lowest	*Stylosanthes scabra*
Highest	*Acacia boliviana*

Seven were suitable to supplement low quality roughages, and 14 were suitable to be fed with grass forage to support milk production.

Determination of acid detergent insoluble nitrogen (ADIN)

A large fraction of the protein in certain legumes may be bound within the cell wall or to compounds such as condensed tannins which give insoluble complexes. This fraction tends to be inaccessible to proteolytic enzymes which are either produced by the rumen micro-organisms or secreted into the small intestine. As a result, this part of the protein is unavailable to the animal. Some measure of its magnitude is important and it is considered that the nitrogenous compounds not rendered soluble by refluxing in acid detergent in the Van Soest procedure are a reflection of this unavailable protein. Values for 13 different species are given in Table 2.

Table 2. *Acid detergent insoluble nitrogen content (expressed as a fraction of total N) of 13 legume species.*

Range	0.091–0.468
Lowest	*Macroptilium atropurpureum*
Highest	*Leucaena diversifolia*

The magnitude of ADIN may bear some relationship to the undegradable N or the condensed tannin content and it would be useful to know if such relationships existed either within or between species.

Assessment of rumen degradability of dry matter (DM) and crude protein (CP)

The proportion of legume forage, either of the total DM or the protein fraction that is degraded in the rumen within certain residence times, is very important in meeting the need for a supplement to improve or maintain an active rumen fermentation from which follow acceptable food intakes and yields of microbial protein. It is recommended that five incubation times e.g. 6, 12, 24, 48 and 96 hours are used together with a zero-time measurement (i.e. losses from the bag as a result of hand-washing). From the results degradation curves can be calculated and compared. Results for 14 species at two incubation times are given in Table 3.

Table 3. *Rumen degradability of DM and CP in 14 legume species.*

Zero time	DM: range	0.24–0.63
	CP : range	0.19–0.58
After 48 h	DM: range	0.57–0.92
CP : range	CP : range	0.57–0.97

High values for zero time degradability indicate that a significant fraction of the forage is rapidly degraded and may be ineffectively utilised.

Ash determination

Certain species of forage such as Napier grass are known to accumulate a high content of ash when grown in certain agro-ecological region. This is a diluting factor on the energy value of the forage since the organic matter as a fraction of dry matter is reduced. Ash contents for 20 legume species are given in Table 4.

Table 4. *Ash content (g/kgDM) of 20 legume species.*

Range	46–100
Lowest	*Leucaena pallida*
Highest	*Sesbania sesban*

Typical ash content of forages and feeds are in the range of 80 to 100 g/kgDM so the values in Table 4 are low to normal.

Determination of Van Soest fibres and lignin

The three fractions which are measured subsequently by extraction processes give some indication of the fibrosity of the forage and the extent to which the fibre can be degraded by the micro-organisms. Neutral detergent fibre (NDF) is an approximate measure of the cell wall content, acid detergent fibre (ADF) is a reflection of cellulose + lignin content while acid detergent lignin (ADL) is a relative but crude measure of the lignin present (Table 5). In general the higher the NDF or ADF content the lower the digestibility of the fibre while high values for lignin are often associated with low digestibility, e.g. as in cereal straws. Ranges for the three constituents in 13 legume species are NDF 339–545; ADF 282–444 and ADL 111–193 g/kg DM.

Table 5. *Content of Van Soest fibre and lignin (g/kgDM) in two legume species.*

	NDF	ADF	ADL
Leucaena pallida	347	31	191
Macroptilium atropurpureum	354	396	121

The 13 species had relatively low NDF and ADF contents, but the high or very high values for ADL indicate that the fibre may not be well digested.

Determination of energy value viz metabolisable energy (ME)

A common route to obtain ME value is to determine organic matter digestibility by an *in vitro* technique based on the work of Tilley and Terry. This value together with the ash content are used to calculate digestible organic matter content from which a ME value can be derived. Unfortunately, digestibility obtained *in vitro* of legume forages may be an under-estimate of that in the live animal due to the presence of anti-nutritional factors which inhibit the fermentation carried out in small tubes. Determination of digestibility *in vivo* is too time-consuming to be a feasible alternative for a large number of species. However, measuring the rumen degradability of the organic matter and applying a correction factor may provide a valid measurement of digestibility.

The energy value of legume forages is important and for certain species it may be surprisingly low. Recent work in Zimbabwe (W. Matizha, personal communication) has shown low ME values for good quality hay made from three common legume species.

Measurement of anti-nutritional factors

It is well known that legume forages, especially shrub legumes contain one or more anti-nutritional factors. The presence of such factors is likely to interfere with the digestion and utilisation of the forages especially the proteins they contain. Of the anti-nutritional factors likely to be present, four types of compounds need to be measured for their content or effects but not necessarily to be fully identified. They are: tannins both condensed and hydrolysable; lectins; saponins; non-protein amino acids e.g. mimosine. Saponins are difficult to determine while the non-protein amino acids need to be known before they can be measured with certainty. Values for condensed tannins and lectins in 14 legume species are given in Table 6.

Table 6. *Content of condensed tannins (g/kgDM) and of lectins (dilution factor) in 14 legume species.*

Condensed tannin range	0–27.4
Lectin range	0–128

Eight out of 14 species had negligible amounts of condensed tannins, and eight out of 14 species had negligible amounts of lectins.

Other determinations and assessments

Two other procedures merit consideration in making an assessment of legume forages for ruminant feeding. Certain species of legumes are known to be low in phosphorus or sodium or both mineral elements. The determination of these two essential minerals should be a routine part of any assessment of suitability for ruminant production systems. Because of the presence of anti-nutritional factors or the possession of other characteristics, legume forages may not be acceptable to ruminant livestock. Acceptability trials using the fresh forage need to be carried out preferably using all three species of ruminant livestock. A minimum number of four animals of each species should be used and the legume forage needs to be provided at supplementary levels with a poor quality roughage such as veld hay for at least ten days.

Conclusions

The results obtained in this study indicate that the suitability of the 20 legumes studied, as supplements in ruminant feeding, is likely to differ appreciably. However, the scheme of assessment outlined may provide a means of selecting the most appropriate legumes for further examination which will need to include production and field trials.

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References

AOAC (Association of Official Analytical Chemists). 1984. *Official Methods of Analysis.* 14th ed. Washington, DC, USA.

Butler L.G., Price M.L. and Brotherston J.E. 1982. *Journal of Agricultural and Food Chemistry* 30:1087–1089.

Hare J. 1992. *The Nutritive Value of Some Tropical Forage Legumes.* MSc thesis, University of Aberdeen, UK.

Ørskov E.R., Hovell F.D. and Mould F. 1980. *Tropical Animal Production* 5:195–213.

Evaluation des légumineuses fourragères comme compléments protéiques ans les systèmes d'élevage de ruminants au Zimbabwe

Résumé

Un système de sélection a été proposé pour évaluer la valeur nutritive de légumineuses arbustives et herbacées pour la complémentation de rations de fourrages grossiers de qualité médiocre ou moyenne dans divers systèmes d'élevage au Zimbabwe. Le matériel végétal a été obtenu en février 1992 (c'est-à-dire pendant la saison des pluies) de centres de recherche situés à Harare et ses environs. Seule la fraction foliaire a été analysée.

Des séries de valeurs ont été attribuées à 20 espèces de légumineuses pour la teneur en protéines brutes (20), l'azote insoluble dans le détergent acide (13), la dégradation dans le, rumen (14) et les taux de matières minérales (20), de parois totales et de lignocellulose (14), de lignine (14) et de facteurs anti-nutritionnels (tanins condensés, lectine). La valeur nutritive des 20 légumineuses était très variable. Ces caractéristiques, définies à partir d'analyses en laboratoire, doivent être validées par des essais d'acceptabilité effectués sur des animaux. Ce système d'évluation pourrait servir à sélectionner les légumineuses les plus approprides à soumettre à une évaluation plus poussée dans le cadre d'essais de production ou d'expériences en milieu réel.

Voluntary dry matter intake and rumen load of cattle fed different tropical forages

A. E. Kimambo, D. M. Mgheni, F. H. Maeda and L.J. Ngi'ngo

Department of Animal Science
Sokoine University of Agriculture
P.O. Box 3004, Morogoro, Tanzania

Abstract

Two experiments were conducted to measure voluntary dry matter intake and rumen load of cattle fed tropical forages. In experiment 1 voluntary dry matter intake of elephant grass *(Pennisetum purpureum)* and rice straw were measured in three fistulated steers. Rumen load was measured by complete evacuation of rumen contents. In experiment 2 voluntary dry matter intake of *Brachiaria brizantha* was measured in 16 dairy heifers.

dry matter (DM) intake per day was 5.2 kg for elephant grass and 3.9 kg for rice straw in steers weighing on average 316 kg and 7.4 kg of *Brachiaria brizantha* in dairy heifers weighing 224 kg. The rumen load expressed as DM weight in the rumen of animals fed *ad libitum* forage differed less: 6.6 kg for elephant grass and 5.8 kg DM for rice straw. It is concluded that the voluntary dry matter intake of elephant grass and rice straw was lower than that of *Brachiaria brizantha.* It appears that rumen load may be good complementary indicator of measuring feeding potential of forages.

Introduction

The dairy industry in urban and peri-urban areas of Morogoro is expanding fast as shown by Njau (1987) and Mlozi et al (1989) who reported increases in both the number of farmers and dairy cattle since 1982. Most of the dairy farmers practice zero-grazing with forages and crop residues that are harvested and transported to their homesteads (Sarwatt and Njau 1990). Tall elephant grass is preferred by farmers (owing to its ease of cutting and carrying on bicycles), to short grasses like *Brachiaria* and *Cynodon* species. Moreover, farmers normally prefer to cut single rather than mixed species grass herbage.

A recent survey of herds in Morogoro revealed that the milk yield is low, ranging from three to eight litres per cow per day (Shekimweri 1992). Inadequate nutrition is the most likely cause of low milk yield, either due to inadequate supplies of feed, or to low intake or low nutrient concentration of the feed consumed.

A series of studies were carried out to investigate these possible factors. In the first study samples of available feed resources were analysed for their nutritive value and their production potential for supporting milk production (Kimambo et al 1993). The predicted intakes of most of the forage species were too low to meet the nutrient requirements for lactating dairy cattle.

To test the reliability of the predicted intake values, it was felt necessary to measure actual forage intake. Therefore the present study measured the voluntary dry-matter intake and rumen load of animals stall-fed three forages to be compared with the predicted values of Kimambo et al (1993).

Materials and methods

Experiment 1

During the wet season in March/April 1993 *Pennisetum purpureum* at an early blooming stage was harvested daily along river banks in the University farm where it grows naturally. It was chopped into 6–7cm pieces using a forage harvester before feeding. Rice *(Oryza sativa)* straw was collected from Dakawa rice farm immediately after grain harvest. It was sprayed with a urea solution (20 g urea/kg DM straw) dissolved in 600 ml of water/kg DM straw and offered immediately.

Both forages were given twice per day *ad libitum* (allowing 15–20% refusals) to three fistulated Boran steers with initial body weights of 400, 288 and 260 kg, respectively. The animals were kept in individual pens and provided with feed and water. They were weighed before and after feeding period of 24 days (14 days adaptation and 10 days of data collection). Feeds offered and refused were weighed daily in the morning, and samples taken regularly for chemical analysis.

Rumen load of the animals was measured two days before the end of each feeding period at 14.00 h by completely emptying the digesta from the cannula. All the liquid was removed and rumen was dried by using a sponge of known weight. The rumen content of each animal was weighed, mixed thoroughly and four samples of about 1000 g each were collected for dry matter determination. The remaining digesta were returned to the rumen of each animal. Rumen load was considered to be equal to the removed rumen content (in kg DM).

Experiment 2

Voluntary dry matter intake of *Brachiaria brizantha* grass was measured using 16 Friesian and Ayrshire dairy heifers ranging between 186 and 244 kg in weight. The animals were confined in individual feeding units supplied with water and feeding troughs.

Grass at the post-bloom stage was harvested daily from established pastures at the University and offered whole twice a day at 9 and 15 h *ad libitum* (allowing 20% refusal). A pre-feeding period of 14 days was followed by 10 days of data collection.

Feed offered and refusals were weighed every day. Feed samples were collected randomly from the plots for chemical analysis before the start of the experiment. Thereafter, random samples were collected daily in the morning and evening during each feeding time. Fresh samples and refusals collected over five days were hand-sorted into stems, leaves, leaf sheaths, dead leaves and panicles. These fractions were weighed separately, then dried and the proportions of each calculated on a DM basis.

Chemical analysis

Dry matter (DM) of feed samples, refusals, botanical fractions, and digesta was estimated by oven drying at 60°C to a constant weight. Crude protein (CP), ether extract, crude fibre, ash, calcium and phosphorus were determined in feeds and refusals according to AOAC (1990) procedures, and neutral detergent fibre according to Goering and Van Soest (1970).

Calculations

Voluntary dry matter intake was expressed as kg DM/day, g DM intake/kg W/day and as a percentage of live weight. Rumen load was recorded as kg DM in the rumen or as a percentage of body weight.

Results

The chemical composition of the three roughages studied (Table 1) reveals that the dry matter content of elephant grass was lower than that of the other two roughages. Similarly, the crude protein content of the three roughages was low ranging from 43 g/kg DM for elephant grass to 54 g/kg DM for urea-sprayed rice straw.

Table 1. *Chemical composition of the feeds (g/kg DM)*

	g /kgDM						
Feed name	DM	CP	CF	Ash	NDF	Ca	P
Pennisetum purpureum	194	43	356	120	752	3.3	1.3
Urea-sprayed rice straw	621	54	395	157	778	3	1.4
Brachiaria brizantha	450	47	–	68	–	–	–

The voluntary DM intake of the three roughages (Table 2) showed that *B. brizantha* had the highest voluntary intake and rice straw the lowest regardless of the method of expressing intake. The intake of leaves and leaf sheaths of *B. brizantha* was higher than that of stems dead leaves and sheaths as shown by the decrease in their proportion in the refusals when compared to their proportion in the feed (Table 3).

Table 2. *Voluntary dry matter intake of three roughages (mean ± SD)*

	DM intake			
Grass species	n	Kg /day	g/kgW/d	% body wt
Pennisetum purpureum	3	5.2±1.08	69.9±15.6	1.69±0.42
Rice straw	3	3.9±1.14	53.0±14.4	1.21±0.43
Brachiaria brizantha	16	7.5±0.01	129±.0.06	3.3±0.01

Table 3. *Proportion of different botanical parts for* Brachiaria brizantha *in the feed and in refusals (1q).*

Botanical fraction	Feed	Refusals
Stem	43.6	59.0
Green leaves	20.2	11.2

Green sheath	19.0	9.3
Dead sheath	3.5	3.6
Dead leaf	7.7	10.2
Panicle	3.8	2.5

The rumen load of steers eating *P. purpureum* was slightly higher than those fed on rice straw although the difference was not significant (Table 4). There was variation in rumen load between animals when load was expressed in kg DM. However, when load was expressed as a percentage of body weight variation between animals was small. Rumen digesta amounted to about 2% of the live body weight when expressed in kg DM and 16% when expressed in kg wet weight.

Table 4. *Rumen load of steers eating two forages (mean ± SD).*

		Rumen load			
		Wet digesta		DM	
Grass species	n	kg	% BW	kg	% BW
P. purpureum	3	53.0±12.3	16.9	6.6±1.55	2.1±0.28
Rice straw	3	46.1±7.5	15.2	5.8±1.03	1.84±0.24

Discussion

The chemical composition of the roughages studied revealed that their CP contents are much lower than that recommended for proper functioning of rumen microbes and for adequate intake of forages. Milford and Minson (1966) have indicated that intake of forages is limited when their nitrogen content is less than 1.0%. The CP values of 43 g/kg DM for *P. purpureum* is slightly higher than 32 g/kg DM the value reported by Kimambo et al (1993) for herbage at 1 month post-bloom but lower than herbage at full bloom (66 g/kg DM). Variation in CP content of *P. purpureum* at different stages of development has been widely reported (Myoya 1980; Mussa 1981; Mwakajumba 1991). Similarly, the CP content of 47 g/kg DM for *Brachiaria brizantha* is lower than that reported by Kimambo et al (1993) of 95 g/kg DM at full bloom and 73 g/kg DM at 1 month post-bloom. The differences in CP content could be due to the location, soil fertility and water availability during grass growth and also the stage of growth at cutting.

The dry matter intake of *P. purpureum* and rice straw are low and affect their production potential. The low dry matter content of *P. purpureum* suggests that intake could be limited by its bulkiness.

Degradability of these forages in other studies have shown low values (Kimambo et al 1993).

Stem structure and proportion of leaves is another factor: *P. purpureum* at bloom stage has a harder stem and lower proportion of leaves than *B. brizantha.* Differences could also be attributed to the type of animals consuming the two grasses. *B. brizantha* was eaten by growing animals which have a higher intake than heavier steers to study intake of elephant grass.

The variation in rumen load between animals when expressed as kg DM of material indicated that the rumen load is related to the size of the animals. The animals used in this experiment weighed 260, 288 and 400 kg. The measured rumen load of the animals was lower than that used for the prediction of intake by Kimambo (1991). This variation could have contributed to the predicted intake values being higher than the actual intake for untreated rice straw and *P*. *purpureum* (Table 5). Intake can be predicted from the rumen load and fill values as reported by Weisbjerg et al (1990) where intake (kg DM/day) = rumen capacity (kg DM)/fill value (day), where the fill value is derived from the degradability characteristics of the feed.

Table 5. *Estimated and actual intake of two roughages.*

	Intake kg DM/day	
Type of roughage	Estimated	Measured
P. purpureum at bloom	6.0	5.2
Untreated rice straw	5.7	3.9

The difference in intake between rice straw and *P*. *purpureum* is greater than that in the rumen load. The intake of *P*. *purpureum* was higher by 24% than that of rice straw, whilst the rumen load of animals eating *P*.*purpureum* was 12% higher. Thus, the rate of degradation and passage (from which fill value is calculated) may affect the intake of roughages. The effective degradability of the *P. purpureum* harvested at the bloom stage was 60% with a degradation rate of 4%/h whilst that of rice straw was 59% with a degradation rate of only 2%/h.

Conclusions

The work has demonstrated that the intake of rice straw and elephant grass is low and cannot meet the requirements for high milk production. Similarly, the intake of *Brachiaria brizantha* is high and can support growing animals. It is therefore recommended that farmers practising a cut-and-carry system should feed heavy species or a herbage mix of several species.

Acknowledgement

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References

AOAC (Association of Official Analytical Chemists). *1990.Official Methods of Analysis. 15th* Edition. AOAC, Washington, DC, USA. *pp.* 69–90.

Goering H.K. and Van Soest P.J., 1970*. Forage Fibre Analysis.* Agriculture Handbook *379. US* Department of Agriculture, Washington, DC, USA. pp. 1–12.

Kimambo A.E. 1991. The use of nylon bag technique to evaluate the feeding value of some tropical feeds (unpublished report).

Kimambo A.E. Weisbjerg M.R. Hvelplund T. and Madsen J. 1993. Feeding value of some tropical feeds evaluated by the nylon bag technique (unpublished report).

Milford R. and Minson D.J. 1966. *Intake of Tropical Pasture Species. Proceedings of the Ninth International Grassland Congress, Sao Paulo.* Departmenta Da Producao Animal Do Secretaria Da Agricultura Do Estado Be Sao Paulo. pp. 15–822.

Mlozi M.R.S., Lupanga LJ. and Mvena Z.S.K 1989. *Urban Agriculture. The Livestock Dimension and its Implications.* Proc. 16th Scientific Conference of Tanzania Society of Animal Production. pp. 197–208.

Mussa M.A. 1981. *The Nutritive Value of Natural Pasture Herbage Ensiled at Three Stages of Growth.* MSc thesis, University of Dar-es-Salaam, Tanzania.

Mwakajumba M.J.B. 1991. *Nutritive Value* of *Various Roughages Used by Smallholder Dairy Farmers in Morogoro Urban and Peri-Urban.* BSc Special Project. Sokoine University of Agriculture, Morogoro, Tanzania.

Sarwatt S.V. and Njau F.B.C. 1990 *Feeding Systems for Smallholder Dairy Farmers in Morogoro Urban.* Proceedings of 17 Scientific conference of Tanzania Society of Animal Production. pp. 98–103.

Shekimweri M.T. 1.992. *Mastitis Incidence: Predisposing Factors and Strategy* of *Control in Smallholder Dairy Farms in Morogoro.* MSc thesis, Sokoine University of Agriculture, Morogoro, Tanzania. pp. 144.

Weisbjerg M.R., Bhargava P.K. and Madsen J. 1990. Use of Degradation Curves in Feed Evaluation. Report No. 679 from the National Institute of Animal Science, Denmark. 33 pp.

Ingestion volontaire de matière sèche et charge du rumen chez des bovins recevant différents fourrages tropicaux

Résumé

Deux essais ont été conduits pour mesurer l'ingestion volontaire de matière sèche et la charge du rumen de bovins recevant des fourrages tropicaux. Dans le premier essai, l'ingestion volontaire de matière sèche d'herbe à eléphant *(Pennisetum purpureum)* et de paille de riz a été mesurée chez trois bouvillons fistulés. La charge du rumen a été estimée en le vidant complètement de son contenu. Dans le second essai, l'ingestion volontaire de matière sèche de *Brachiaria brizantha* a été mesurée chez 16 génisses laitières.

L'ingestion journalière de matière sèche (MS) était de 5,2 kg d'herbe à éléphant et de 3,9 kg de paille de riz chez les bouvillons pesant 316 kg et de 7,4 kg de *B. brizantha* chez des génisses de 224 kg. La charge du rumen, exprimée en kilos de matière sèche trouvée dans le rumen des bouvillons recevant du fourrage à volonté, ne variait pas significativement en fonction du fourrage, s'établissant à 6,6 kg de MS pour l'herbe à éléphant et à 5,8 kg de MS pour la paille de riz. Ces résultats montrent que l'ingestion volontaire de matière sèhe de *P. purpureum* et de paille de riz était inférieure à celle de *B. brizantha. Il* apparaît également que la charge du rumen est un bon indicateur complémentaire de la qualité nutritionnelle des fourrages.

Rumen degradability of dry matter and protein in tropical grass and legume forages and their protein values expressed in the AAT-PBV protein evaluation system

D. M. Mghen[1], T. Hvelplund[2] and MR Weisbjerg[2]

[1]Department of Animal Science and Production, Sokoine University of Agriculture
P.O. Box 3004, Chuo Kikuu, Morogoro, Tanzania
[2]Department of Research in Cattle and Sheep, Research Centre Folum,
P.O. Box 39, DK-8830, Tjele, Denmark

Abstract

An experiment was conducted with three rumen fistulated dry Friesian cows to estimate rumen degradability of dry matter (DM) and protein in tropical grass and legume forages, using the nylon bag technique. Amino acid absorption from the small intestine (AAT) and protein balance value in the rumen (PBV) were estimated according to the AAT-PBV protein evaluation system. The results showed that tropical grass and legume forage varied substantially in rumen degradability of both dry matter and protein when evaluated on the degradation constants a, b and c, respectively. At a passage rate of 2% per hour, the calculated protein degradability varied between 32 and 84%. This implies that for some of the feeds the amount of undegraded dietary protein leaving the rumen is an important fraction. The actual digestibility of the undegraded fraction was low varying between zero and 42%. The value of the undegraded dietary protein in these feeds is consequently low and the major supply of amino acids to the animal is generated by microbial protein produced in the rumen. The AAT potential of the different feeds varied between 33 and 60 g per kg DM and the PBV value varied quite substantially from 28 to 125 g per kg DM. The low intestinal digestibility of the undegraded dietary protein in these feeds indicates that utilisation of the protein is only possible through an increased degradability in the rumen and conversion of this degraded protein to microbial protein.

Introduction

In ruminants the protein value of a feed or a diet has been more accurately estimated using total amino acids truly absorbed in the small intestine (ARC 1984; NJK 1985; NRC 1985; Verite and Peyrand 1989) than in the system based on digestible crude protein (DCP). The two principal parameters in these new systems are protein degradability in the rumen and intestinal digestibility of the undegraded dietary protein. Degradability of protein in the rumen is considered a variable in all systems and has been estimated with the nylon bag technique (Orskov and McDonald 1979; Kristensen et al 1982). In the French PDI-system (Verite and Peyrand 1989), true intestinal digestibility of undegraded rumen protein (UDP) varies between 0.55 and 0.95, depending on classes of feeds while it is kept at a constant value for all classes of feeds in all other systems. Variations as applied in the PDI-system clearly demonstrate that digestibility of UDP in the small intestine is not a constant value (Hvelplund et al 1992; Volden and Harstad 1992). It has also been found that preincubation of some tropical forages in the rumen significantly ($P<0.001$) increased the maximum digestibility, which increased with increasing incubation time in the rumen (Mgheni et al 1993).

The aim of the present study was to evaluate the protein value of tropical grass and legume forages based on the AAT-PBV system, which measures ammino-acid absorbtion from the small intestine (AAT) together with the protein balance in the rumen (PBV).

Materials and methods

Feed samples

Tropical grasses viz.: Bana grass *(Pennisetum purpureum* × *Pennisetum typhoides)* cut at the height of 1.5 m; *Brachiaria brizantha* (cut before full bloom and at a height of 75 cm); *Cenchrus ciliaris, Chloris gayana* and *Panicum maximum* (all post-flowering; 75 cm to lm height); *Pennisetum purpureum* (height 1.5 m) and *Tripsacum fasciculatum* (height of 1 m) were used. Tropical legumes viz:*Desmodium intortum* (flowering stage); *Desmodium uncinatum* (inter-cropped with *Tripsacum fasciculatum* and before full bloom); *Neonotonia wightii* (post-flowering with young green pods); *Pueraria phaseoloides* (cut at the flowering stage) and *Leucaena leucocephala* (legume shrub; whole plant and leaves, collected when green pods were formed) were used in this study. Random samples were collected from the field and dried at 60°C to constant weight, ground to pass through a 2.5 mm sieve, packed and air-freighted to the Research Centre at Folum, Denmark, where the experiment was conducted.

Chemical analysis

The chemical composition of all feedstuffs was done by estimation of DM and ash content as outlined by AOAC (1990). The nitrogen (N) content was determined using macro – Kjdeldahl as outlined by AOAC (1990). Water insoluble ash (WIA) in all samples was determined by soaking the test feed in 50 ml of distilled water (20°C) for 1 h in glass fibre crucibles of known weight.

The porous base was rubber-stoppered to prevent water loss. The samples were washed with distilled water (4 x 50 ml) through a vacuum pump. The residue was air dried and ached in a muffle furnance at 525°C for 5 h. The HCL fat was determined according to the procedure outlined by Stoldt (1952).

Animals and feeding

Three rumen fistulated dry Friesian cows were used; they were fed 5.4 kg DM of good quality hay (156 g crude protein (CP/kg DM) plus 2.6 kg DM of concentrate (184 g CP/kg DM) per cow per day. The animals were fed twice per day at 9 and 16 h and had free access to water. The feed diet allowance was slightly above maintenance.

Rumen degradability

Rumen degradability of nitrogen (N) was determined using the nylon bag technique as described by Kristensen et al (1982) and recently modified by Madsen and Hvelplund (1993). About 1 g of each sample was weighed into the nylon bag (NY36HD) with a pore size of 36×36 µ.m and an effective size of 7×19 cm. The bags were made to have a round base to avoid feed particles being trapped into sharp corners. Rumen incubation times of 0, 8, 16, 24, 48, 96, 144 and 192 h were used. For each sample, one bag was used for each incubation time and repeated in three cows. The bags were inserted during the morning feeding time. After each incubation time the bags were removed from the rumen, rinsed to remove adhering rumen feed particles and immediately deep frozen to arrest microbial activity. After the longest incubation time all bags together with the zero-hour bags were machine-washed in cold water for 15 min.

The samples were treated in a stomacher to remove microbial contamination (Sharpe and Jackson 1972). The feed samples were washed back from the stomacher bags into the nylon bags, washed through with cold water until the water was clear. The residues were dried in an oven at 100°C for 20 h, weighed for residue DM content and finally analysed for N-content according to standard procedure (AOAC 1990). A factor of 6.25 was used to obtain the value of protein.

Calculations

Description of the degradation profile

The degradation profile of protein for each forage was described using the mathematical model of Ørskov and McDonald (1979):

$$p = a + b(1 - e^{-ct}) \qquad (1)$$

where p = degraded fraction (%) at time t

a = water soluble fraction (%)

b = water insoluble but potentially degradable fraction (%)

c = rate at which b is degraded (rate constant) (%/h)

t = incubation time (h)

The data were analysed using the SAS program Proc NLIN (SAS 1985) for estimation of degradation constants.

Effective degradability

Effective degradability (ED) of N in all feed samples was calculated using a passage rate of 2%/h according to the formula of Ørskov and McDonald (1979):

$$ED = a + [(b(c/(c + k)))] \qquad (2)$$

where

ED = effective degradability and a, b, and c are the constants as described in equation (1) and k is the outflow rate (%/h).

Actual intestinal digestibility of UDP

The actual intestinal digestibility of UDP was calculated using values obtained from Mgheni et al (1993) on rumen degradability of protein and true intestinal digestibility of intact feed protein and UDP after pre incubation in the rumen for 0, 8, 24 and 96 h.

Estimated AAT-PBV values

The AAT-PBV values were calculated according to the Nordic AAT-PBV system (NKJ 1985). Effective degradability of protein was calculated using a passage rate of 2%/h instead of 8%/h as used in the Nordic system. Digestible carbohydrate (DCHO) was calculated from the equation:

DCHO = [(1000 – CP) (ED of PFDM/100)] – (WSA + 0.4 HCl fat) (3)

where

DCHO = digestible carbohydrate (g/kg)

CP = crude protein (g/kg)

ED of PFDM = effective degradability of protein-free dry matter (g/kg)

WSA = water soluble ash (g/kg)

0.4 HCl fat = digestible fat (g/kg) assuming 40% of the fat disappeared from the nylon bag

Results

Chemical composition

Chemical composition of the feeds is shown in Table 1. The CP content ranged from 93 to 125 for grasses and 118 to 259 g/kg DM for legumes species. As expected the CP content of legume species was generally higher than that of grasses. A similar trend was observed for HCl-fat. Total ash was higher in grasses (93 to 121 g/kg DM) than in legumes (55 to 85 g/ kg DM).

Table 1. *Chemical composition of tropical grass and legume forages (g/kg DM).*

Feedstuff	Crude protein	HCl-fat	Total ash	Water insoluble ash
Grasses				
Bana grass	93.1	25.0	112.7	44.0
Brachiaria brizantha	107.5	40.0	92.7	31.9
Cenchrus ciliaris	113.8	28.0	96.7	27.6
Chloris gayana	76.9	24.9	97.2	50.1
Panicum maximum	107.5	32.3	109.1	46.4

Pennisetum purpureum	103.8	26.9	120.9	43.4
Tripsacum fasciculatum	125.0	27.0	92.7	18.4
Legumes				
Desmodium intortum	118.1	31.1	55.1	16.0
Desmodium uncinatum	163.1	38.2	85.2	26.8
Neonotonia wightii	177.5	39.3	76.1	20.5
Pueraria phaseoloides	150.6	31.6	57.2	19.0
Shrubs/trees				
Leucaena leucocephala				
Whole	242.0	43.6	62.7	14.3
Leaves	259.4	70.7	109.2	29.3

Rumen degradation and effective degradability (ED)

The rumen degradation constants a, b, and c values obtained from equation (1) are given in Table 2. The soluble fraction (a) in DM (a-DM) ranged from 17 to 31% for grasses and 18–30% for legumes. This range showed that there was not much difference between grass and legumes species although the CP, the total ash, the water soluble ash, and HCl-aDM fat varied substantially (Table 1). The grass *Brachiaria brizantha* had the highest a-DM (31 %) followed by the legume, *Neonotonia wightii* (30%); the lowest a-DM's of 17% and 18% were found in *Chloris gayana* (grass) and *Desmodium intortum* (legume) respectively. Except for *Leuceana,* the a-value for N was higher than for DM, and in *Neonotonia* and *Brachiaria* the water soluble fraction was close to 50%. The insoluble but potentially degradable fraction (b-values) for DM ranged between 56 and 65% for grasses and 36 to 46% for legumes. This showed a higher potential degradability of DM (b-value) for grasses than for legumes. A smaller variation was observed for bN between grasses (47–68%) than between legumes (22–51%), which may suggest an anti-nutritional factor in some of the legumes. The rate constant c at which b is degraded for DM (cDM) ranged between 2.4 to 4.2%/h for grasses and 2.8 to 7.1 %/h for legumes.

Table 2. *Degradability constants for dry matter (DM) and nitrogen (N) ± (BEM).*

	Degradability constants (%)			
	a		b	
Forages	DM	N	DM	N
Grasses				
Bana grass	21.4±1.7	27.8±2.3	59.3±2.0	58.2±2.6
Brachiaria brizantha	30.5±1.7	46.0±2.5	55.9±1.9	46.8±5.8
Cenchrus ciliaris	18.2±1.4	34.7±0.8	57.7±1.6	47.0±0.9
Chloris gayana	17.0±1.4	25.6±3.6	59.1±1.7	55.1±4.6
Panicum maximum	21.7±l.5	34.7±2.7	61.213.1	56.0±3.0
Pennisetum purpureum	18.0±2.6	24.6±2.9	63.0±3.0	60.5±3.6
Tripsacum fasciculatum	20.0±2.3	22.7±3.7	64.6±27	67.9±4.4
Legumes				

Desmodium intortum	17.7±1.0	21.4±0.6	35.5±1.1	21.6±0.1
Desmodium uncinatum	20.9±0.8	29.1±2.2	45.7±0.9	42.3±2.6
Neonotonia wightii	29.9±1.4	49.6±1.6	44.1±1.6	38.5±1.8
Pueraria phaseoloides	24.2±1.3	32.5±0.9	42.5±1.5	51.0±1.0
Tropical shrub/tree				
Leucaena leucocephala				
Whole	24.4±0.9	25.6±2.6	44.9±0.9	50.0±3.7
Leaves	40.2±2.4	25.1±4.6	52.2±2.7	72.3±5.0
	Asymptote a + b		C	
	DM	N	DM	N
Grasses				
Bana grass	80.7±0.02	86.6±0.02	3.6±0.3	3.5±0.4
Brachiaria brizantha	86.4±0.02	92.8±0.33	4.2±0.3	5.8±0.8
Cenchrus ciliaris	75.9±0.02	81.8±0.00	3.4±0.2	3.4±0.2
Chloris gayana	76.1±0.02	80.7±0.06	2.4±0.2	2.0±0.0
Panicum maximum	82.9±0.01	90.8±0.03	3.1±0.2	4.2±0.0
Pennisetum purpureum	80.9±0.02	85.1±0.05	2.7±0.4	2.0±0.0
Tripsacum fasciculatum	84.6±0.03	90.7±0.02	2.8±0.3	2.0±0.0
Legumes				
Desmodium intortum	53.2±0.01	43.0±0.01	2.8±0.2	2.0±0.0
Desmodium uncinatum	66.6±0.01	71.5±0.02	3.710.2	2.4±0.0
Neonotonia wightii	74.0±0.02	88.0±0.02	7.1±0.6	7.0±0.0
Pueraria phaseoloides	66.7±0.02	83.6±0.01	5.5±0.4	4.0±0.0
Tropical shrub/tree				
Leucaena leucocephala				
Whole	69.3±0.00	75.6±0.02	4.2±0.2	3.7±0.5
Leaves	92.5±0.01	97.4±0.04	8.7±1.0	8.5±1.3

The rate constant c for N (cN) was more or less similar to that of the cDM ranging from 2.0 to 5.8%/h for grasses and 2.0 to 7.0%/h for legumes. The ED of the grass and legume forages using different passage rates (1, 2, 3 and 4%/h) is given in Table 3. The influence of rates of passage of particles out of the rumen on the ED value for both DM and N is clearly demonstrated in Table 3, and this stresses the need for an estimate of this important factor in applying the values for ration formulation.

Table 3. *Effective degradability (ED) of dry matter (DM) and nitrogen (N) for tropical grass and legume forages calculated at four different passage rates from the equation ED = a+ [(b(c/(c + k))].*

Forages	Effective degradability (%) at four different passage rates (%/h)							
	1		2		3		4	
	DM	N	DM	N	DM	N	DM	N
Grasses								
Bana grass	67.8	73.1	59.5	64.8	53.7	59.2	49.5	55.0
Brachiaria brizantha	75.7	85.9	68.4	80.8	63.1	76.8	59.1	73.7
Cenchrus ciliaris	62.8	71.0	54.5	64.3	48.9	59.7	44.7	56.3
Chloris gayana	58.7	62.3	49.2	53.2	43.3	47.6	39.2	44.0
Panicum maximum	68.0	79.9	58.9	72.6	52.8	67.4	48.4	63.4
Pennisetum purpureum	64.0	64.9	54.2	54.9	47.8	43.4	44.8	
Tripsacum fasciculatum	67.6	68.0	57.7	56.7	51.2	49.9	46.6	45.3
Legumes								
Desmodium intortum	43.9	35.8	38.4	32.2	34.8	30.0	32.3	28.6
Desmodium uncinatum	56.9	59.0	50.6	52.2	46.1	47.9	42.9	45.0
Neonotonia wightii	65.9	83.3	62.0	79.5	59.0	76.6	56.2	74.1
Pueraria phaseoloides	60.2	73.3	55.4	66.5	51.7	61.6	48.8	58.0
Tropical shrub/tree								
Leucaena leucocephala								
Whole	60.7	65.0	54.8	58.1	50.6	53.2	47.4	49.6
Leaves	87.0	89.8	82.6	83.6	79.0	78.5	76.0	74.3

Total amino acid absorbed from the small intestine (AAT) and protein balance in the rumen (PBV)

The AAT and PBV values calculated with a protein degradability based on a 2% passage rate for the tropical grass and legume forages are given in Table 4. Given are also the digestible carbohydrate (DCHO), AAT originating from microbial amino acid (AAT-MIC), and AAT originating from the rumen undegraded feed protein (AAT-UDP). The actual intestinal digestibility of UDP and the values of AAT obtained by using these values in the calculation are also given in Table 4.

Table 4. *Amino acids absorbed from UDP (AAT-UDP) calculated with a constant digestibility or estimated with the actual digestibility, digested carbohydrates (DCHO), amino acids absorbed from microbial protein (AAT-MIC), and amino acids absorbed from the intestine AAT and the protein balance in the rumen (PBV), (g/kg DM).*

Feedstuff	DCHO	AAT-UDP[1]	Actual digestibility of UDP	AAT-UDP[2]
Grasses				

Bana grass	451.8	17.3	0.199	4.20
Brachiaria brizantha	534.4	11.1	0.281	3.82
Cenchrus ciliaris	400.6	21.7	0.108	2.85
Chloris gayana	389.7	18.9	0.365	8.39
Panicum maximum	451.8	15.5	0.000	0.00
Pennisetum purpureum	389.4	23.0	0.160	4.49
Tripsacum fasciculatum	412.8	24.2	0.172	4.07
Legumes				
Desmodium intortum	303.0	44.0	0.010	0.54
Desmodium uncinatum	343.1	41.0	0.048	2.40
Neonotonia wightii	427.1	19.6	0.424	10.13
Pueraria phaseoloides	391.7	26.1	0.0332	10.56
Tropical shrub/tree:				
Leucaena leucocephala				
Whole	339.7	53.9	0.000	0.00
Leaves	505.8	23.9	0.029	0.84
	AAT	AAT-MIC	AAT[3]	PB V
Grasses				
Bana grass	65.3	48.0	52.2	–0.1
Brachiaria brizantha	67.9	56.8	60.2	–8.2
Cenchrus ciliaris	64.2	42.6	45.5	+1.6
Chloris gayana	60.3	41.4	49.8	–28.1
Panicum maximum	63.5	48.0	48.0	–2.3
Pennisetum purpureum	64.4	41.4	45.9	–8.9
Tripsacum fasciculatum	68.0	43.9	49.0	+5.9
Legumes				
Desmodium intortum	76.2	32.2	32.7	–18.6
Desmodium uncinatum	77.5	36.5	38.9	–24.8
Neonotonia wightii	65.0	45.4	55.5	+64.5
Pueraria phaseoloides	67.7	41.6	52.2	+31.7
Tropical shrub/tree				
Leucaena leucocephala				
Whole	90.0	36.1	36.1	+80.2
Leaves	77.5	53.7	54.6	+124.5

1 Digestibility of UDP calculated using a factor of 0.82 (NKJ/1985).

2 Calculated using the actual digestibility of UDP.
3 Calculated with AAT-UDP[2].

The actual digestibility of UDP was considerably lower than the values 0.82 originally used in the AAT-PBV system; some of them were even zero. The corrected AAT values varied between 46 and 60 g AAT per kg DM for grasses and between 33 and 56 for legumes, and were considerably lower than the values calculated according to the system in which a factor of 0.82 is used for digestibility of undegraded dietary protein.

The PBV values were negative for most of the grass species with the exception of *Tripsacum fasciculatum* (+ 5.9 g PBV/kg DM) and *Cenchrus ciliaris* (+ 1.6 g PBV/kg DM). For legumes the PBV values were positive and higher than those of grasses, except for the *Desmodium* species, which were negative and slightly lower than those of grasses despite their relatively high CP contents (Table 1). This suggests a poor protein utilisation of *Desmodium* in the rumen.

Discussion

The expression of the protein value of a feed as the amount of amino acids absorbed in the small intestine (AAT) requires knowledge of different factors in the feed as outlined in the AAT-PBV protein evaluation system (Hvelplund and Madsen 1990). An important factor in the determination of the protein value is the degradability of the feed protein in the rumen. A reliable estimate of this degradation can be obtained from the duodenal flow of protein in cannulated animals, in which the microbial fraction can be quantified by an accurate marker (Hvelplund and Madsen 1985). This method is both expensive and laborious, and a good alternative to this procedure is the nylon bag technique (Ørskov and McDonald 1979), in which estimated values for degradation constants can be obtained. For calculation of degradability it is, however, necessary to know the rate of passage of particles out of the rumen. The influence of rate of passage is clearly demonstrated in Table 3. The reduction in degradability is much higher when the rate of passage is increased from 1 to 2% compared with an increase from 3 to 4% per hour. Estimation of the exact rate of passage is therefore very important, especially in the low range of passage rates for estimation of effective degradability and of the amount of undegraded protein passing to the small intestine. The outflow rate of particles out of the rumen is difficult to determine experimentally and has not been performed on these feeds. A passage rate of 2% applied in the calculations of degradability was found appropriate. As shown in Table 3, the degradabilities in some of the feeds, where comparisons were possible, were similar to published values for digestibility (Göhl 1981). The protein degradability calculated at a passage rate of 2%/h varied between 55% and 81% for grasses and between 32% and 80% for legumes. The contribution of undegraded dietary protein passing into the small intestine for some of the feeds can be quite substantial, and therefore both the proportion of amino acids in the undegraded protein and their subsequent digestion in the small intestine is of importance.

The proportion of amino acids in the undegraded dietary protein from roughages is kept as a constant in the AAT-PBV system, assuming that 65% of the undegraded crude protein is amino acid protein. This has been justified for a number of temperate roughages, as discussed by Hvelplund (1986), but needs further clarification for tropical feeds and in particular for feeds with a low degradability and a high protein content, for which the contribution of undegraded dietary protein is important.

The digestibility of amino acids in the undegraded protein was originally kept as a constant in the AAT-PBV system (Hvelplund and Madsen 1990) but has later been changed according to the principles outlined by Hvelplund et al (1992) in which the digestibility is calculated based on information on degradability and intestinal digestibility of the original protein. The principle behind this method is that the maximum availability of the protein is obtained from the intestinal digestibility of the original protein. This hypothesis was tested on tropical roughages by Mgheni et al (1993) and found invalid for these feeds, probably because a high proportion of the protein is bound to the cell walls and consequently not digestible in the intestine but still degradable in the rumen, where both cellulolytic and proteolytic activity are present simultaneously. Based on the results of Mgheni et al (1993) the digestibility of the undegraded protein in these feeds was calculated by extrapolation from values of degradability in the rumen and digestibility of the protein after pre-incubation in the rumen.

The AAT value of the undegraded protein calculated using either the original system based on a fixed digestibility of 82% or the actual estimated values is shown in Table 4. The contributions of absorbed amino acids from the undegraded protein taking the actual digestibility into account is reduced quite substantially compared to the situation where a fixed digestibility of 82% is applied. This stresses the importance of estimating the actual digestibility of the undegraded protein in tropical feeds. The low digestibility of the undegraded protein, which varies between zero and 44%, is probably caused by a high proportion of cell-wall-bound protein in the undegraded fraction but antinutritional factors may be of importance in this respect (D'Mello 1992).

The microbial protein synthesis in the rumen is related to the amount of energy made available duri fermentation in the rumen. In the AAT-PBV system, the microbial protein synthesis is related to the amount of digested carbohydrates (Hvelplund and Madsen 1990). Carbohydrate digestion was not measured in this experiment but was estimated as the amount of protein-free dry matter degraded from nylon bag incubation after corrections for soluble ash and degraded fat as outlined in equation 3. The microbial amino acid synthesis in the rumen is calculated from the carbohydrates digested assuming that one kg carbohydrate produces 125 g microbial amino acids (Hvelplund and Madsen 1990). The digestibility of the microbial amino acids in the small intestine is considered as a constant of 85% (Tas et al 1981; Storm et al 1983 and Hvelplund 1985) and this value is used to calculate the AAT value from the microbial protein synthesis.

The sum of amino acids absorbed from microbial protein and undegraded dietary protein make up the AAT value of the feed. The AAT values based on the actual digestibility of the undegraded dietary protein will in all cases be substantially lower than a value based on a constant digestibility of the undegraded protein as originally proposed for the AAT-PBV system. Further, the AAT values for the legumes included in this study do not contribute a protein supply, that is superior to the grasses and this is in particular so for the *Desmodium* species.

The PBV value is the difference between degraded protein and the amount used for microbial protein synthesis (microbial amino acid synthesis/0.70 assuming 70% of the amino acids are microbial protein as discussed by Hvelplund (1986)). This value is shown for the different feeds in Table 4. Negative values are obtained for both grasses and legumes, and show that the amount of protein degraded in the rumen is insufficient to meet the microbial requirement. The opposite was the case for *Leucaena,* where high positive PBV values were obtained, indicating that this feed is a good source for supplying degraded protein to the rumen microbes.

Conclusions

Tropical grass and legume forages showed substantial variation in the rumen degradability of both DM and protein and their effective degradability when calculated at a passage rate of 2%/h. The protein degradability estimated in all feeds contributed a significant amount of undegraded protein to the small intestine. The actual digestibility of this fraction of protein is found to be low, varying between zero and 42%, and consequently, the amino acid supply to the animal from this fraction is limited.

The major supply of amino acids to be absorbed from the small intestine is from microbial protein produced in the rumen. The AAT potential of the different feeds varied between 33 and 60 g per kg DM, while the PBV value varied quite substantially, from 28 to 125 g per kg DM. The low intestinal digestibility of the undegraded dietary protein in these feeds indicate that improved utilisation of the protein is only possible through an increased degradability in the rumen and conversion of this degraded protein to microbial protein.

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References

AOAC (Association of Official Analytical Chemists). 1990. *Official Methods of Analysis.* 15th ed. Arlington, Virginia, USA.

ARC (Agricultural Research Council) 1984. *Report of the Protein Group of the Agricultural Research Council Working Party on the Requirements of Ruminants.* Commonwealth Agricultural Bureau. 45 pp.

D'Mello J.P.F. 1992. Chemical constraints to the use of tropical legumes in animal nutrition. *Anim. Feed Science Technology.* 38:237–261.

GÖhl B. 1981. *Tropical Feeds.* FAO, Rome. 529 pp.

Hvelplund T. 1985. Digestibility of rumen microbial protein and undegraded dietary protein estimated in the small intestine of sheep or by *in sacco* procedure. *Acta Agric. Scand,* Suppl. 25:132–144.

Hvelplund T. 1986. The influence of diet on nitrogen and amino acid content of mixed rumen bacteria. *Acta Agric. Scand.* 36:325–331.

Hvelplund T. and Madsen J. 1985. Amino acid passage to the small intestine in dairy cows compared with estimates of microbial protein and undegraded dietary protein from analysis on the feed. *Acta Agric. Scand.* Suppl. 25:21–36.

Hvelplund T. and Madsen J. 1990. A study of the quantitative nitrogen metabolism in the gastrointestinal tract, and the resultant new protein evaluation system for ruminants. The AAT-PBV system. The Royal Veterinary and Agricultural University, Copenhagen. 215 pp.

Hvelplund T., Weisbjerg M.R. and Andersen L.S. 1992. Estimation of the true digestibility of rumen undegraded dietary protein in the small intestine of ruminants by the mobile bag technique. *Acta Agric. Scand.* Sect. A, Animal Sci. 42:34–39.

Kristensen E.S., Moller P.D. and Hvelplund T. 1982. Estimation of the effective protein degradability in the rumen of cows using the nylon bag technique combined with the outflow rate. *Acta Agric. Scand.* 32:1231–127.

Madsen J. and Hvelplund T.1993. Prediction of *in situ* protein degradability in the rumen. Results of a European ringtest. *Livest. Prod. Sci.* (in press).

Mgheni D.M., Hvelplund T. and Weisbjerg M.R. 1993. Intestinal digestibility of rumen undegraded dietary protein of tropical roughages estimated by the mobile bag technique. *Acta Agric. Scand.,*Sect. A, Animal Sci. (submitted).

NKJ. 1985. Introduction of the Nordic protein evaluation system for ruminants into practice and further research requirements. *Acta Agric. Scand.* Suppl. 25:216–220.

NRC (National Research Council) 1985. *Ruminant Nitrogen Usage.* National Academy Press, Washington, DC,USA 138 pp.

Ørskov E.R. and McDonald I. 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to the rate of passage. *Journal of Agricultural* Science 92:499–503.

SAS. 1985. *Statistical Analysis System*. SAS Users Guide. Statistics. SAS Institute Inc. Version 5. North Carolina, USA. 956 pp.

Sharpe AN and Jackson A.K. 1972. Stomaching. A new concept in bacteriological sample preparation. Appl. Microbiology 24:175–178.

Stoldt W. 1952. Vorslag zur Vereinheitlighung der Fettbestimmung in Lebensmitteln. Fette and Seifen. 54:206–207.

Storm E., Brown D.S. and Ørskov E.R. 1983. The nutritive value of rumen microorganism in ruminants. 3. The digestion of microbial amino and nucleic acids in and losses of endogenous nitrogen from the small intestine of sheep. *Br. J. Nutr.* 50:479–485.

Tas M.V., Evens R.A, and Axford R.F.E. 1981. The digestibility of amino acids in the small intestine of the sheep. *Br. J. Nutr. 45:167–174.*

Verite R and Peyrand J.L. 1989. Protein. The PDI System. In: Jarnge R. (ed.), *Ruminant Nutrition.* INRA. pp. 33–47.

Volden H. and Harstad O.M. 1992. Bestemmelse av fordøyeligheten i tarmen av ikke nedbrutt fØrprotein. HusdyrforsØksmØtet Norges LandbrukshØgskole, 24 26 marts 1992. No. 13:561–566.

Dégradabilité de la matière sèche et des protéines de graminées et légumineuses fourragères tropicales dans le rumen, et mesure de leurs valeurs protéiques suivant le système d'évaluation protéinique AAT-PBV

Résumé

Un essai a été réalisé sur trois vaches sèches de race Frisonne fistulées pour évaluer la dégradabilité de la matière sèche (MS) et des protéines de graminées et légumineuses fourragères tropicales dans leur rumen par la technique d'incubation des sacs en nylon. L' absorption des acides aminés à partir de l'intestin grêle (AAT) et le bilan azoté dens le rumen (PBV) ont été déterminés par le système d'évaluation protéinique AAT-PBV. Il ressort des résultats obtenus que cette dégradabilité variait considérablement lorsqu'elle était calculée respectivement suivant les constantes de dégradation a, b et c. Au rythme de passage de 2% par heure, la dégradabilité des protéines variait de 32 à 84%. Cela signifie que pour certains des aliments, la quantité de protéines alimentaires quittant le rumen sans être dégradées était importante. La digestibilité réelle de cette fraction non dégradée était faible, allant de 0 à 42%. Ces protéines alimentaires non dégradées n'ont donc qu'une valeur limitée, les protéines microbiennes produites dens le rumen constituent la principale source d'acides aminés. Le potentiel de l'AAT des différents aliments variait entre 33 et 60 g/kg de MS; quant au bilan azoté, il fluctuait de façon considérable de 28 à 125 g/kg de MS. La faible digestibilité des protéines alimentaires non dégradées au niveau de l'intestin indique que l'utilisation des protéines ne peut être améliorée que par l'accroissement de leur dégradabilitée dens le rumen et la conversion de ces protéines dégradées en protéines microbiennes.

Effect of ensiling maize stover with alfalfa or urea on intake, digestibility and nitrogen balance by growing lambs

F.B. Bareeba[1] and KE McClure[2]

[1]Deparment of Animal Science, Makerere University
[2]OARDC, Wooster, USA

Abstract

Preservation of maize stover as silage makes it possible to preserve plant nutrients that otherwise would be lost by physiological activity or leaching. Maize stover is deficient in nitrogen and energy. Maize stover was ensiled with alfalfa or urea to study the effect of additional nitrogen on its utilisation by growing lambs. Stover was collected after a high moisture grain harvest, adjusted to 35% DM with water and ensiled as 1) untreated stover 2) stover:direct-cut alfalfa (60:40 DM basis); 3) urea-treated stover (1% wet basis); 4) stover: direct-cut alfalfa (80:20 DM basis) + 0.5% urea (wet basis of stover portion). Addition of urea to stover caused a less desirable fermentation compared to alfalfa addition. The silages were fed to growing lambs (40 kg BW) in a 4 × 4 Latin square digestion and N balance trial. Lambs on diet 1 were supplemented with alfalfa pellets (17% CP) at 22% of the stover DM intake to raise dietary CP to 8.2%. Crude protein levels for the silages were 5.6%, 10.9%, 14.2% and 11.9%, respectively. Dry-matter intake was similar on diets l and 2 but was lower ($P<0.05$) on diets 3 and 4. Digestion coefficients for DM were similar among diets except for diet 3 which was lower ($P<0.05$) than diet 2. Crude protein digestibility differed ($P<0.05$) among diets being highest on diet 3 (70.4%) and lowest on diet 1 (47.9%). Digestion coefficients of NDF and ADF did not differ among diets. Nitrogen balance was negative on all diets but lambs on diet 1 and 2 had higher ($P<0.01$) nitrogen balance than those on diets 3 and 4. Alfalfa improved the utilisation of stover compared to urea in this study.

Introduction

Maize crop residue (stover) can be an inexpensive source of forage, and it may be grazed, stacked or ensiled. Preservation of maize stover as silage makes it possible to preserve plant nutrients that otherwise would be lost by physiological activity or leaching, offering the possibility of using stover in rations for growing animals.

Keys and Smith (1981) compared maize stover silage to stover/grain silage, supplementing both silages with dried poultry excreta as a source of nitrogen. Growth of dairy heifers was similar for the diet containing maize stover silage (710 g/day) and the maize silage diet (770 g/day). However, intakes for maize stover silage diets were lower than for maize silage, probably because the levels of maize stover silage in the diets were extremely high, thus limiting energy intake. Colenbrander et al (1971) fed maize stover with urea, ammonium polyphosphate or both to dairy heifers that gained 500 g/day. They concluded that growth could be improved by increasing the energy content of the diet.

Other good quality forages like alfalfa have a much higher nitrogen content than maize silage and would not require additional nitrogen supplementation. Combination of alfalfa hay with ammonia-treated maize cobs or stalks had a beneficial effect on animal growth and digestion in sheep and steers compared with untreated cobs and stalks (Paterson et al 1981).

The objective of the present study was to determine effect of ensiling maize stover with direct-cut alfalfa or urea on intake and utilisation by growing lambs.

Materials and methods

Ensiling

Maize stover was harvested with a New Idea Uniharvester fitted with a flail cutter head and a 10.2 cm chopper chamber screen. Harvesting was done immediately after removal of 22% moisture grain. Stover was adjusted to 35% DM and ensiled in double plastic bags (96 × 165 cm). Treatments were: 1) untreated stover 2) stover:direct-cut alfalfa (60:40 DM basis); 3) urea treated stover (1% wet basis); 4) stover: direct-cut alfalfa (80:20 DM basis) + 0.5% urea (wet basis of stover portion). Alfalfa was harvested at 31% DM. All mixtures were firmly packed by trampling to remove as much air as possible and the bags were individually sealed. The mixtures were allowed to ferment for a minimum of 40 days before feeding.

Metabolism trial

The four silages were each fed *ad libitum* once daily to four Polypay wether lambs weighing about 40 kg in a 4 × 4 Latin square design with periods of 21 days. Lambs fed the untreated stover were supplemented with alfalfa pellets (17% CP) at 22% of the stover DM intake. Lambs were fed for a 7-day preliminary period followed by a 7-day voluntary intake period and a 7-day collection period. They were housed in a climate-controlled room and maintained in digestion crates. Ten grams of iodised salt were added to the diet at each feeding and water was available *ad libitum.*

During the collection period, animals were offered 90% of their voluntary feed DM intake so that there were no orts. Urine was collected in buckets containing 50 ml 5% HCL and the volume was measured daily and 10% aliquot was composited and stored at 2°C for later analysis. Faeces were weighed daily and composited and refrigerated in plastic bags. At the end of the collection period, the faeces were mixed and 500 g subsamples were saved. Feed samples were taken daily composited and refrigerated for future analysis.

Feed and faeces were analysed for DM, crude protein and ash by AOAC (1990) procedures. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were analysed according to Goering and Van Soest (1970). Silage extracts were prepared as described by Bareeba et al (1983).

The pH of the extracts was determined electrometrically and samples were used for subsequent determination of lactic acid (Barker and Summerson 1941), volatile fatty acids (Colenbrander et al 1983) and NH3-N (Bareeba et al 1983). Data were analysed according to the GLM procedure of SAS (1985).

Results and discussion

Fermentation characteristics and chemical composition

Addition of urea to stover silage tended to cause a less desirable fermentation as indicated by the higher pH and butyric acid and lower lactic acid content (Table 1). The results are in agreement with previous reports (Colenbrander et al 1971). Lactic acid contents of the two alfalfa diets were high indicative of good quality silage. Keys and Smith (1984) was ensiled with alfalfa (60, 40). Ammonia nitrogen (NH3-N) was higher in urea-treated silage indicative of urea hydrolysis or proteolytic activity. Johnson et al (1967) reported that proteolytic activity is increased in silage fermentation with urea addition.

Table 1. *Fermentation characteristics of maize stover silage.*

	Silage				
Item	Untreated	40% alfalfa	urea	20% alfalfa + urea	SE[e]
PH	4.09[a]	4.19[a]	6.47[b]	4.29[a]	0.16
Composition of DM,%					
Lactic acid	7.75[b]	9.48[c]	1.05[a]	11.09[d]	0.22
Acetic acid	1.28[b]	1.67[b]	0.61[a]	1.55[d]	0.11
Butyric acid	0.0	0.0	5.30	0.0	–
NH3-N (% total N)	2.07[d]	1.82[a]	18.07[c]	5.63[b]	0.25

abcd Means in the same row with different superscript differ significantly (P<0.05).

e Standard error of the mean.

Addition of urea or alfalfa increased the crude protein content of the silage (Table 2) in agreement with previous workers (Colenbrander et al 1971; Keys and Smith 1984). As expected, the alfalfa diets had a more desirable structural composition as evidenced by their lower NDF and ADF contents. Urea additions to maize stover and maize silage tended to decrease the structural components of the silage (Huber et al 1968; Colenbrander et al 1971). This was not the case in the present study.

Table 2. *Chemical composition of maize stover silages fed to growing lambs.*

	Silages			
Item	Untreated	40% alfalfa	Urea	20% alfalfa + urea
Dry matter, %	33.7	34.6	34.8	35.3
Composition of DM,				
CP	5.6	10.9	14.2	11.9
NDF	71.1	58.2	70.4	63.5
ADF	45.5	38.3	46.0	41.2
Ash	10.5	10.3	10.3	10.7

Metabolism study

Dry matter intake for lambs on the 40% alfalfa diet was higher (P<0.05) than for those on the 20% alfalfa diet or urea treated stover (Table 3). Supplementing the untreated stover diet with alfalfa pellets resulted in DM intake similar to the one on 40% alfalfa diet. Increased consumption of low quality roughages treated with poultry excreta or ammonia have been reported (Keys and Smith 1981; Paterson et al 1981). Keys and Smith (1984) reported decreased DM intake by heifers when fed a diet containing 60% maize stover silage and 40% alfalfa compared to maize silage or alfalfa silage diets.

Table 3. *Intake and apparent digestibility of maize stover silages by growing lambs*

	Silages				
Item	Untreated	40% alfalfa	Urea	20% alfalfa + urea	SEM
Dry matter intake					
g/d	826.0[a]	807.3[a]	578.9[c]	655.2[b]	15.6
8/Kg $^{0.75}$/d	53.8[a]	53.2[a]	38.3[c]	43.7[b]	1.1
Digestion coefficients,%					
DM	49.8[ab]	53.2[a]	47.5[b]	50.4[ab]	1.1
CP	47.9[c]	57.9[b]	70.4[a]	62.8[b]	1.6
NDF	44.6	6.6	46.5	45.4	1.1
ADF	43.2	47.0	43.5	42.8	1.4

abc Means in the same row with different superscripts differ significantly (P<0.05).

Dry matter digestibility was higher (P<0.05) for the 40% alfalfa diet compared to the urea-treated stover diet. Crude protein digestibility was higher (P<0.05) for the urea treated stover compared to the other diets, and this may be due to increased NH_3 - N loss from the rumen (Bergen, 1975). Paterson et al (1981) reported no positive associative effects on DM digestibility by lambs from the addition of 50% alfalfa to ammoniated maize stalks. Digestibility of the fibre fractions were similar among treatments in agreement with Keys and Smith (1984).

Daily nitrogen intake was different (P<0.01) among the diets, being highest (11.9 g) on the 40% alfalfa diet and excretion followed a similar trend (table 4). Urinary nitrogen loss was higher (P<0.01) for lambs on urea-treated stover diets compared to untreated or alfalfa diets, probably due to lack of energy as reflected in reduced DM intake on the urea treatment. Colenbrander et al (1971) concluded that growth of dairy heifers could be improved by increasing the energy content of maize stover. Nitrogen balance was negative for all the diets, indicating that the protein requirements of the lambs were not met (NRC 1985). However, lambs on the untreated or 40% alfalfa diet had better (P<0.01) nitrogen balance compared to those on the urea diets.

Table 4. *Nitrogen balance of growing lambs fed corn stover silages.*

	Silages				
Item	Untreated	40% alfalfa	Urea	20% alfalfa+urea	SEM
Nitrogen intake, g/d	9.34[d]	11.89[a]	11.06[b]	10.54[c]	0.14
Nitrogen excretion, g/d					

Faecal	4.86[a]	5.05[a]	3.30[c]	3.94[b]	0.15
Urinary	5.59[d]	7.38[c]	11.23[a]	8.95[b]	0.22
Total	10.45[c]	12.43[b]	–3.47[c]	12.89[b]	0.25
Nitrogen retention, g/d	–1.11	–.54[a]	47.5[b]	–2.35[b]	0.24

abcd Means in the same row with different superscripts differ significantly (P<0.01).

Results of this study indicate that addition of alfalfa to maize stover enhances the nutrient composition without producing any detrimental influence on silage fermentation. Alfalfa addition improved the utilisation of maize stover compared to urea addition.

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References

AOAC (Association of Official Analytical Chemists). 1990. *Official Methods of Analysis* (15th ed.). Washington, DC, USA.

Bareeba F.B., Ingalls LR., McKirdy LA and Sharma H.R. 1983. Apparent digestibility and nutritional value of urea or ammonia solution treated corn silage for lactating Holstein cows and manure sheep. *Canadian Journal of Animal Science* 63:871.

Barker S.B. and Summerson W.H. 1941. The calorimetric determination of lactic acid in biological materials. J. *Biol. Chem.* 138:535.

Bergen W.G. 1975. *Influence of Silage Fermentation on Nitrogen Utilization.* Proceedings of the 2nd International Silage Research Conference, Chicago. p. 171.

Colenbrander V.F., Mullet L.D., Wasson J.A. and Cunningham M.D. 1971. Effects of added urea and ammonium polyphosphate to corn stover silage on animal performance. *Jounal of Animal Science* 33: 1091.

Goering H.K. and Van Soest P.J. 1970. *Forage Fibre Analysis (Apparatus, Reagents, Procedures and Some Applications).* Agriculture Handbook 379, Department of Agriculture, Washington, DC, USA, 20 pp.

Huber J.T., Thomas J.W. and Emery R.S. 1968. Response of lactating cows fed urea-treated corn silage harvested at varying stages of maturity. J. *Dairy Sci.* 51:1806.

Johnson R.R., McClure K.E., Klosterman E.W. and Johnson L.J. 1967. Corn plant maturity III. Distribution of nitrogen in corn silage treated with limestone, urea and diammonium phosphate. J. *Anim. Sci.* 26:394.

Keys J.E. and Smith L.W. 1981. Effect of ensiling corn stover with alfalfa on growth, intake and digestion by yearling dairy heifers as compared with whole corn plant silage. J. *Dairy Sci.* 67:1971.

NRC(Natural Research Council). 1985. *Nutrient Requirements of Sheep.* 6th rev. ed. National Academy of Science, Washington, DC, USA.

Paterson J.A., Klopfestein T.J. and Britton R.A. 1981. Ammonia treatment of corn plant residues: digestibilities and growth rates. J. *Anim. Sci.* 53:1592.

SAS. 1985. SAS *User's Guide: Statistics.* SAS Inst. Inc. Cary, North Carolina, USA.

Effet de l'ensilage des tiges de maïs avec de la luzerne ou de l'urée sur l'ingestion, la digestibilité et le bilan azoté chez les agneaux en croissance

Résumé

La conservation des tiges de maïs sous forme d' ensilage permet de préserver les éléments nutritifs qui, autrement, seraient éliminés par l'activité physiologique ou le lessivage. Les tiges de maïs sont pauvres en azote et en énergie. Elles ont été ensilées avec de la luzerne ou de l'urée en vue d'étudier l'effet de l'apport d'azote sur leur utilisation par des agneaux en croissance. Elles ont été ramassées après la récolte de grains à l'état pâteux, et leur taux d'humidité a été ajusté à 35% de MS avec de l'eau. Elles ont ensuite été ensilées: I) sans traitement; 2) mélangées avec de la luzerne coupée sur place (sur la base de 60:40 de MS); 3) traitées avec de l'urée (1% sur la base du poids humide), et 4) mélangées avec de la luzerne coupée sur place (sur la base de 80:20 de MS) et additionnées d'urée à 0,5% (sur la base de la fraction humide des tiges). La luzerne a entraîné une meilleure fermentation que l'urée. L'ensilage a été servi à des agneaux en croissance (40 kg de poids vif) répartis selon le dispositif expérimental du carré latin (4 × 4) pour tester leur digestion et leur bilan azoté Les animaux soumis à la ration 1 ont requ comme complément alimentaire du fourrage condensé de luzerne (17% de protéines brutes), représentant 22% de l'ingestion de MS de tiges, afin de porter la teneur en protéines brutes (PB) alimentaires à 8,2%. Les faux de PB pour les quatre ensilages étaient respectivement de 5,6; 10,9; 14,2 et 11,9%. La consommation de MS était similaire pour les rations 1 et 2, mais plus faible (P<0,05) pour les rations 3 et 4. Les coefficients de digestion de la MS étaient analogues, excepté pour la ration 3 pour lequel il était inférieur (P<0,05) à celui de la ration 2. La digestibilité des PB variait selon la ration (P<0,05) allant de 70,4% pour la ration 3 à 47,9% pour la ration 1. Les coefficients de digestion des fibres NDF et ADF étaient similaires. Le bilan azoté, négatif pour toutes les rations, était cependant plus élevé pour les rations 1 et 2 (P<0,01) que pour les deux autres. Cette étude montre que la luzerne améliore plus l'utilisation des tiges de maïs que l'urée.

Studies into the productivity and ensilage of "wild sorghum" *(Sorghum arundihaceum)* for dry season ruminant feeding

J.E. Fleischer and A.M. Tackie

Department of Animal Science, University of Ghana
P.O. Box 226, Legon, Accra, Ghana

Abstract

The dry matter yield, the fermentation characteristics and the nutritive value of ensiled "wild sorghum" *(Sorghum arundinaceum)* was studied. Seeds of "wild sorghum" were sown in a nursery and transplanted at 0.25 m within and 0.50 m between rows on plots of 3.0 m × 3.0 m. Fertiliser was applied at the rate of 20 kg N and 20 kg P_20_5 per hectare. Three harvests were made: the first at 12 weeks after planting followed by harvests at 22 and 32 weeks. The second and third harvests were used for silage by cutting herbage into 3–5 cm long pieces and packing them in doubly lined polythene bags (1.0 kg per bag). There were four herbage treatments: T_1 untreated, T_2: treated with formic acid (0.5%), T_3: untreated but wilted for six hours in the sun, T_4 combined with *Leucaena* in a ratio of 7:3 of fresh weight. All bags were ensiled for 112 days. Samples were taken before ensiling and on opening of the bags for analysis of dry matter (DM), total nitrogen (T-N), neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose, acid detergent lignin (ADL) and *in vitro* dry matter digestibility (IVDMD). Silage was in addition analysed for ammonia nitrogen and total organic acids.

Total dry matter yield over the 32 weeks was 29.3 t.DM/ha with an average values of total N (T-N), IVDMD and hydrogen cyanide HCN of 0.86%, 45.8% and 335 mg/kg DM, respectively. Combining "wild sorghum" with leucaena raised T-N and IVDMD to 3.84% and 60.0%, respectively. The values for the T_1, 7_2, T_3 and T_4 silage were: pH: 5.18, 4.36, 5.37 and 5.25; T-N: 0.92, 0.92, 0.91 and 3.62; ammonia nitrogen as % of % T-N 12.5, 12.4, 18.4 and 7.6%. Total organic acids were 1.77, 1.81, 2.23 and 1.74 × 10^5 mg; HCN: 182, 181, 136 and 99 mg/kg and IVDMD: 38.9, 39.9, 37.7 and 42.3%, respectively.

Introduction

Ruminant livestock in Ghana largely depend on natural grasslands for their feed supplies. Consequently, ruminant livestock lose weight in the dry season which may last between four and six months. Hence, attempts are being made to conserve feed resources for the dry season. However, farmers find it difficult to use maize and/or sorghum for silage making because these are staple foods. One grass which has potential for silage but has not been studied and grows in natural vegetation in Ghana is the wild sorghum *(Sorghum arundinaceum).* The objective of this research was to study the dry matter yield, the fermentative quality and the nutritive quality of sorghum herbage both fresh and ensiled.

Materials and methods

Location

The experiment was carried out at the Department of Animal Science, University of Ghana, Legon (5°39"N; 0° 11 "W), near Accra. The average maximum and minimum monthly temperatures are 31.5°C and 23.7°C. Annual rainfall is on average 735 mm, relative humidity falls between 68 and 100%, whereas annual evapotranspiration averaged 1625 mm (Walker 1962).

Plant material and productivity

The land was ploughed and harrowed. Seeds of wild sorghum were initially sown in a nursery and seedlings transplanted two weeks later on plots 3.0 m × 3.0 m in size. Planting was done at 0.25 m within and 0.50 m between rows. Two weeks after transplanting fertiliser was applied at the rate of 20 kg N and 20 kg P_20_5 per hectare by banding along the rows. There was regular manual weed control using hoe and cutlass. The field was irrigated from the nearby standby pipe when necessary. Harvesting was first done after twelve weeks growth, and two subsequent harvests were done at 10 weeks interval.

Silage making

The secondary and tertiary regrowths were chopped up into 2–3 cm lengths with cutlass and used for ensiling. Polythene bags of 0.15 mm thickness were doubled and used as silos. There were four treatments namely: T_l untreated sorghum; T_2 treated with formic acid (0.5%); T_3: untreated but wilted in the sun for six hours; T_4: combined with leucaena (grass:legume 7:3, fresh wt). These were packed into bags (about 1.0 kg) and ensiled for 112 days.

Chemical analysis

Samples were taken both before and after ensiling and analysed for dry matter, total nitrogen (% T-N) and hydrogen cyanide (HCN) according to AOAC (1975); neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose and acid detergent lignin (ADL) according to Goering and Van Soest (1970) and *in vitro* dry matter digestibility (IVDMD) according to Minson and McLeod (1972). The silages were additionally analysed for pH, ammonia nitrogen and total organic acid following Marckham (1942).

Statistical analysis

The results were analysed statistically according to Snedecor and Cochran (1976).

Results

The dry matter yield, chemical composition and IVDMD of the "wild sorghum" is shown in Table 1 and Table 2. No differences ($P<0.05$) were observed among dry matter yields which was about 9.8 t DM/ha at each harvest of 10 weeks growth. Total nitrogen content was lower ($P<0.05$) for the first harvest but about the same for the two subsequent ones. HCN contents of the first harvest was lower but similar for the other harvests. IVDMD was lowest in the first and highest in the second harvest which is in agreement with the trends in NDF, ADF, cellulose and ADL.

Table 1. *Dry matter yield, chemical composition and IVDMD of wild sorghum at harvest.*

Harvest	DM yield (t/ha)	%DM						HCN (mg/kg)
		TN	NDF	ADF	Cellulose	ADL	IVDMD	
First	9.54^{a}	0.68^{a}	82.5^{a}	50.50^{a}	43.19^{a}	6.06^{a}	40.97^{a}	307.4^{a}
Second	9.71^{a}	0.96^{a}	76.9^{b}	45.21^{b}	35.85^{b}	6.78^{b}	54.29^{a}	364.2^{a}
Third	10.07^{a}	1.00^{b}	79.2^{ab}	49.67^{ab}	36.76^{b}	6.96^{b}	47.14^{a}	333.63^{a}
Average	9.77	0.86	79.6	68.46	38.60	6.60	45.84	335.4
LSD	0.95	0.316	4.0	4.5	5.4	0.6	23.420	99.9

abc Figures in the same column with different letters are significant at 5%.

Table 2. *Chemical composition of the three forages before ensiling.*

	DM (%)	%DM						HCN (mg/kg)
		TN	NDF	ADF	Cellulose	ADL	IVDMD	
Sorghum	24.4^{a}	0.95^{a}	77.7a	47.4^{a}	36.3^{a}	67.0^{a}	47.2^{a}	354.8^{a}
Leucaena	29.3^{a}	5.54^{b}	33.7^{b}	22.1^{b}	14.6^{b}	5.67^{b}	66.2^{b}	
Sorghum + *Leucaena*	28.5^{a}	3.84^{c}	66.9^{c}	33.5	25.8^{c}	6.2^{ab}	59.5^{ab}	252.0^{b}

abc Figures in the same column with different letters are significant at 5%.

Because of the similarity of the second and third harvest forage they were bulked together. The chemical composition of the forages used for silage showed that the grass had lower ($P<0.01$) crude protein content and IVDMD but higher NDF and cellulose compared to *leucaena* whereas ADL content was similar. Mixing grass and *leucaena* reduced the cell wall constituents but raised crude protein and IVDMD values, while lignin content remained the same. Because the *leucaena* contained no HCN its inclusion decreased its content in the silage.

The fermentation characteristics of the silage is shown in Table 3. The pH of the formic acid-treated silages were significantly ($P<0.05$) lower than the others which did not differ ($P>0.05$). There was a slight decrease in T-N% compared to that in fresh herbage while in the grass-legume N content was the same at pre- and post-ensilage. Volatile basic nitrogen was relatively high in all the silages with that of T_3 being the highest and T_4 lowest and significantly different from the others. Total organic acid in T_3 was higher ($P<0.05$) than the others which did not differ ($P<0.05$).

Table 3. *Fermentation characteristics of silage.*

Treatment	DM%	PH	T-N	$(NH_3\text{-}N)/T\text{-}N$	(Total organic acid x)/ 10^5u/100g
T_1	21.0^{a}	5.18^{a}	0.92^{a}	12.50^{a}	1.77^{a}
T_2	23.6^{a}	4.3^{b}	0.92^{a}	12.44^{a}	1.81^{a}
T_3	35.0^{a}	5.37^{a}	0.91^{a}	18.37^{b}	2.23^{b}
T_4	21.5^{a}	5.25^{a}	3.62^{a}	7.56^{c}	1.74^{a}

abc Figures in the same column with different letters are significant at 5%.

The cell wall constituents, HCN and IVDMD of the silages are shown in Table 4. Except for the changes observed in Table 2, the cell wall constituents were not affected by ensiling. Ensiling decreased the HCN whereas wilting and *leucaena* inclusion decreased it further. IVDMD in T_4 was higher ($P<0.05$) than the others, but lower in the ensiled compared to the unensiled material (Table 2).

Table 4. *Cell wall composition and* in vitro dry *matter digestibility of silage.*

	% DM					
Treatment	NDF	ADF	Cellulose	ADL	IVDMD	HCN (mg
T_1	73.5[a]	48.1[a]	35.9[a]	6.8[a]	38.9[a]	182.3[a]
T_2	72.8[a]	45.4[b]	36.1[a]	6.9[a]	39.9[a]	180.7[a]
T_3	71.9[a]	46.7[ab]	34.4[a]	6.9[a]	37.7[a]	135.9[b]
T_4	60.9[b]	43.2[c]	25.0[b]	6.0[b]	42.3b	98.8[c]
LSD	2.5	2.5	2.3	0.6	2.4	10.9

abc Figures in the same column with different letters are significant at 5%.

Discussion

The dry matter yield of almost 30 mt/ha per year is much higher than could be obtained from most natural grassland (Boudet 1975; Caldwell 1975) and compares favourably with that obtained from many cultivated grasses (Doppler 1980). This would feed about 18 cattle with a daily requirement of 10 kg DM or about 190 sheep and goats requiring about 1 kg DM daily for a dry period of five months.

The higher crude protein content of the second and third harvest might have been due to a lag effect of applied nitrogen fertilisers. Despite this, the crude protein content in all grass-silages was lower than the threshold level of 7–8% (1.1–1.3% N) below which intake is reduced (Milford and Minson 1965). Thus, the consumption of this grass is expected to be low. The cell wall constituents of the first harvest were higher than those of second and third harvests because the former grew for a longer period (12 weeks) compared to the latter (10 weeks). The difference between the "wild sorghum" and *leucaena* is consistent with reported literature (Norton 1981) and adding legume to the grass improved the crude protein content and digestibility of the ensiled product.

The slight decrease in dry matter content after ensiling may be due to the fermentation of water-soluble carbohydrates. The high pH of the silages has also been reported by others (Miller 1969; Catchpoole and Henzel 1971). The high organic acid of the wilted silage is due an increased concentration of water soluble carbohydrates available for fermentation.

The ammonia nitrogen, expressed as fraction of total nitrogen was high in all silages except the legume-grass mixture. It is reported that silage quality is poorer with increasing ammonia nitrogen concentration (Coshima and McDonald 1978). The higher NH_3-N value of wilted silage was unexpected and can not be explained. While the grass–legume mixture showed the smallest ratio it produced the highest ammonia and total nitrogen content. The low IVDMD of the ensiled material was probably due to low organic matter content, which was not determined (Brown and Radcliffe 1970).

Conclusions

This research has shown that the annual dry matter production of the wild sorghum can be very high and may support more livestock than natural grassland. Although the nitrogen content of the harvested material is relatively low, it can be improved by the inclusion of *leucaena* or any other palatable shrub or tree leaves, which can easily be ensiled. It remains to be seen whether ruminants can achieve high intakes and local farmers will adopt silage making.

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References

AOAC (Association of Official Analytical Chemists). 1975. *Official Methods of Analysis.* 12th edition. AOAC, Washington, DC, USA.

Boudet G. 1975. The inventory and mapping of rangeland in West Africa. In: *Evaluation and Mapping of Tropical African Rangelands. Proceedings of the Seminar Held in Bamako, Mali,* 3–8 March 1975, ILCA (International Livestock Centre for Africa). pp. 57–77.

Brown D.C. and Radcliffe J.C. 1970. A new method of preparing ground silage for the determination of chemical composition and *in vitro* digestibility. In: *Proceedings of the 11th International Grasslands Congress. Suffers, Paradise, Australia. pp.* 750–754.

Caldwell W. 1975. Primary production of grazing lands. In: Cooper J.P. (ed), *Photosynthesis and Productivity in Different Environments.* IBP3, Cambridge University Press, Cambridge, U.K. pp. 41–73.

Catchpoole V.R. and Henzel E.F. 1971. Silage and silage making from tropical herbage species. *Herb. Abst.* 41:213–221.

Coshima M. and McDonald P. 1978. A review of the change in nitrogenous compounds of herbage during ensilage. *J. Se. Food Agric.* 29:497–505.

Doppler W.1980. *The Economics of Pasture Improvement and Beef Production in Semi-humid West Africa.* German Agency for Technical Cooperation (GTZ), Eschborn, Germany. 195 pp.

Goering H.K. and Van SoestP.J. 1970. *Forage Fibre Analysis.* Agriculture Handbook 379. US Dept of Agriculture, Washington, DC, USA. 20 pp

Milford R. and Minson D.J. 1965. Intake of tropical pasture species. Proc. 9th Int. Grassl. Cong., Sao Paulo, Brazil. pp. 815–828.

Miller T.B. 1969. Forage conservation in the tropics. *J. Brit. Grassl. Soc.,* 24:158–162.

Minson D.J. and McLeod M.N. 1972. *The* In vitro *Technique. Its Modification for Estimating Digestibility of Large Number of Tropical Pasture Samples.* CSIRO, Div. of Trop. Past., Tech. Pap. No. 8.

Norton B.W. 1981. Differences between species in forage quality. In: Hacker J. B. (ed) *Nutritional Limits to Animal Production from Pastures.* Commonwealth Agricultural Bureaux, Farnham Royal, UK. pp. 89–110.

Rose Innes R. 1977. *A Manual of Ghana Grasses.* Land Resources Div., Min. Overseas Dev., Tolworth Tower, Surbiton, England. 265 pp.

Snedecor G.W. and Cochran, W.G. 1976. *Statistical Methods.* 6th edition. The Iowa Univ. Press, Ames, Iowa, USA. 593 pp.

Thomas C. and Thomas P.C. 1987. Factors affecting the nutritive value of grass silage. In: *Recent Advances in Animal Nutrition.* Butterworth, London, UK. pp. 274–307.

Etude de la productivité et de l'ensilage de *Sorghum arundinaceum* comme aliment de saison sèche des ruminants

Résumé

Le rendement de matière sèche, la valeur nutritive et les caractéristiques de la fermentation d'un ensilage de *Sorghum arurrdinaceum* ont été étudiés. Après le semis en pépinière, les plants de S.*aruyrdinaceum* ont été repiqués sur des parcelles de 3 m sur 3 avec des espacements de 0,5 m entre les lignes et des écarts de 0,25 m. Les parcelles ont été fertilisées avec 20 kg N et 20 kg P_205 pr hectare. Trois coupes ont été effectuées, la première 12 semaines après le semis, les deux autres respectivement à 22 et 32 semaines. On a ensilé le produit des deuxième et troisième coupes en hachant l'herbe en morceaux de 3 à 5 cm de long et en l'emballant dans des sacs en plastique à double épaisseur (1 kg par sac). Quatre traitements ont été testés, à savoir T1, témoin (non traité); T2, traité à l'acide formique (0,5%); T3, non traité, mais préfané au soleil pendant 6 heures et T4, mélangé à *Leucaena* suivant un rapport de 7 à 3 de poids frais. Tous les sacs ont été incubés pendant 112 fours. Des échantillons ont été prélevés avant et après l'ensilage pour déterminer les faux de matière sèche (MS), d'azote total (% de TN), de fibres (NDF), de lignocellulose (ADF), de cellulose, et de lignine a (LI) ainsi que la digestibilite *in vitro* de la matiere sèche (DIVMS). Les teneurs en azote ammoniacal et en acides organiques totaux des ensilages ont également été déterminées.

Le rendement total de matière sèche du fourrage coupé à 32 semaines était de 29,3 t de MS/ha et les valeurs moyennes du faux total d'azote, de la DIVMS et du cyanure d'hydrogène (HCN) étaient respectivement de 0,86%, 45,8% et 35 mg/kg de MS. Dans le mélange avec *Leucaerra,* le faux total d'azote et la DIVMS étaient passés respectivement à 3,84 et 60%. Pour les quatre traitements TI, T2, T3 et T4, les valeurs suivantes ont respectivement été observées pour le pH: 5,18; 4,36; 5,37 et 5,25; pour la teneur en azote total (% de TN): 0,92; 0,92; 0,91 et 3,62%; pour le faux d'azote ammoniacal par rapport à la teneur en azote total :

12,5; 12,4; 18,4 et 7,6%; pour la quantité totale des acides organiques: 1,77; 1,81; 2,23 et 1,74 x 10^5 mg; pour le HCN: 182,181,136 et 99 mg/kg et pour la DIVMS: 38,9 39,9 ; 37,7 et 42,3%.

Conservation of forage for dry season feeding in the humid zone of Nigeria

A. T. Davies and C.F. I. Onwuka

Department of Animal Nutrition, College of Animal Science and Livestock Production, University of Agriculture, P.M.B. 2240, Abeokuta, Ogun State, Nigeria

Abstract

Forage of *Pennisetum purpureum* and leaves of *Gliricidia sepium* were harvested during the late wet season and conserved as hay and silage as potential feeds for rural smallholders with livestock. Their nutritive values were monitored over a 4-week period. The hays contained 14–15% moisture and were still mould-free after four weeks. Crude protein content in the grass hay was 5.9% compared to 14.3% in the legume hay; CP content in the fresh material was 11.0% and 21.8%, respectively, indicating substantial losses during the hay making process, in contrast to fibre content which rose slightly to 37%.

The grass–legume silage contained 32% moisture, 11% CP and 27% crude fibre whether treated with formic acid (at 2.7 g/kg fresh wt) or not. Quality was enhanced by adding ground maize (45 g/kg) and molasses (35 g/kg). After four weeks, pH was 4.3 in the control and 5.5 in the treated silage.

Due to their high quality, hay-making and ensilage of grass–legume mixtures are recommended. It is believed that farmers can use these conservation techniques on-farm provided they have sufficient labour and can obtain forage during the late wet season either from their own farm or from communal savannah land in their vicinity.

Introduction

In livestock enterprises, one of the most important factors determining profitability is to achieve optimal levels of feeding. This aim is most problematic during the dry season when available feed is scarce and of low quality. A "staircase" growth pattern is observed when animals are not adequately fed during the dry season. Therefore, livestock farmers are facing their biggest challenge during the dry season (Ikhatua and Adu 1984). Producing supplementary feed on farm by establishing grass/legume pastures would reduce this problem. For instance, mixed grass/legume pasture produced higher dry matter yields of better nutritive value than sole grass swards (Onifade and Akinola 1986). However, as both grasses and legumes decline in quality as the dry season progresses (Adejumo and Ademosun 1985), ways of preserving nutritive quality through hay making or ensiling during the rainy season may be worthwhile (Duru and Columbani 1992).

The DM intake of forage can be significantly improved by ensilage (Olayiwole and Olorunju 1986). Animal performance on crop residues can be improved by chemical treatment and by supplementation with concentrates. Thomas (1982) showed that silage treated with formaldehyde improved the utilisation of silage protein while Van Soest and Goering (1970) indicated that this treatment may induce the cleavage of lignin-carbohydrate bonds, resulting in a more soluble products. The major aim of silage fermentation is to achieve a stable pH at which biological activity virtually ceases (Gordon 1989). Wilting herbage prior to ensilage may not necessarily increase animal performance, but may improve fermentation characteristics.

This project was designed to study hay- and silage-making methods that could assist farmers to see their ruminant animals through the dry season. Specifically, changes in nutritive values of conserved forage over specific time periods were monitored.

Materials and methods

Two forage species, *Gliricidia sepium* and *Pennisetum purpureum,* which are widely used in the day-to-day feeding of ruminants in the humid and subhumid zones of south-western Nigeria, were the focus of the study. Their leaves were cut and collected during the late rainy season. The cut herbage of *Pennisetum* consisted of about 10 weeks regrowth while the *Gliricidia* leaves represented five months growth.

Four batches of 5 kg each of freshly cut *Pennisetum purpureum* and *Gliricidia sepium* leaves were evenly spread on a dry clean floor and sun-dried for 2–3 days while turned every three hours to ensure uniform drying.

The hays were then baled and stored on wooden pallets within an open-sided roofed building and the quality was monitored over a 4-week period.

The collected forage for ensilage was wilted for 24 hours in the field and then chopped into 10 cm lengths. Four batches of 5 kg of wilted grass–legume mixture were ensiled separately with two treatments: with and without formic acid. They were packed in black polytlene bags together with the following additives: formic acid (to the treated silage only) at 2.7 g/kg; ground maize 45 g/kg; salt (NaCl) 14 g/kg; 35 g/kg of molasses as a spray. The ensiled materials were well consolidated in the polybags during and after filling. Each bag was then tied securely. Quality was monitored after one and four weeks. Samples were subjected to proximate chemical analyses using the A.O.A.C. (1984) procedures. Determination of pH was done on the aqueous extracts of silage. The data were subjected to statistical analysis according to Steel and Torrie (1980).

Results

Sun-drying the cut herbage for 2–3 days with frequent turning was effective and reduced moisture content from 69–72% to 14–15%. No further moisture loss of grass herbage and legume leaves occurred during the four weeks of storage. The protein level of the grass hay declined gradually with time but stabilized at 5.9% after four weeks. Conversely, the fibre content of the grass hay rose (P>0.05) to 37.9% (Table 1). In the legume hay, the level of crude protein fell from 22 to 14% but was still more than twice as high as in the grass hay (Table 1). Crude fibre content in the two hays was similar. In both hays no mould was observed throughout the experimental period.

Table 1. *Proximate composition of* Pennisetum *and* Gliricidia *after cutting (fresh), one and two weeks when stored as hay* (916 *DM)*

	Pennisetum	*Gliricidia*

	Fresh	After 1 wk	After 2 wks	Fresh	After 1 wk	After 2 wks
Dry matter	28.0	85.0	85.3	30.8	83.0	83.8
Crude protein	11.0	6.8	5.9	21.8	17.9	14.3
Crude fibre	34.5	35.4	37.9	31.4	35.4	36.0
Ash	9.8	8.8	5.9	9.1	7.1	6.2
Ether extract	1.4	1.0	1.0	4.3	2.1	2.0

The silages made from the grass–legume mixture contained about 11 % CP and 26–28% and fibre were not affected by the formic acid treatment (Table 2). The rate of nutrient change was low; crude protein fell by 3.7% and crude fibre increased slightly over the 4 week period. Overall, the pH levels fell from 6.3 to 4.3 in the control silage, being more acidic than in the treated silage. The addition of ground maize and 3.5% molasses acted as fermentation stimulants, i.e. as energy-yielding substrate for lactic acid production.

Table 2*. Proximate composition and pH of untreated and formic-acid treated silage of* Pennisetum–Gliricidia *leaves (% DM).*

	Untreated			Treated		
	Fresh	After 1 wk	After 2 wks	Fresh	After 1 wk	After 2 wks
Dry matter	23.5	69.8	67.9	23.5	68.8	68.1
Crude protein	14.7	12.0	11.0	14.7	11.8	11.1
Crude fibre	33.1	31.4	28.0	33.1	31.7	26.8
Ash	9.1	8.5	7.1	9.1	8.2	7.4
PH	16.3	5.6	4.3	6.9	6.6	5.5

Discussion

The low moisture levels in the hay prevented mould in the stored forage throughout the experimental period, and also inhibited microbial growth. According to Merchen and Satter (1983) the fall in the protein content of the hay may be due to volatilisation.

According to Akinola (1989) partial wilting increases DM content which reduces bacterial activity in the silage. The pH reduction indicates proper fermentation since Patterson (1990) noted that an increase in pH during storage was associated with an increase in ammonia-nitrogen and a decrease in total acids; therefore adding formic acid to the silage caused a slower rate of pH reduction. The rapid release of the initial effluent from the formic acid treatment was particularly striking and is in agreement with earlier observations by Henderson and McDonald (1977).

Small-scale livestock farmers at the village level own on average 1–4 goats and 1–3 sheep (Ekpenyong and Onwuka 1987). During the dry season from December to April when feed resources dwindle in quantity and quality, feed conserved as hay and silage may assist to see small ruminants through this harsh period. A farmer with 10 smallstock will need 0.5 kg/head/day of supplement or about 750 kg of forage for the 5-month dry period. Since there are no sown pastures in southern Nigeria and forage is not sold commercially, farmers have to rely on forage supplies from communally owned uncultivated savannah land. Since only labour is needed in the acquisition and conservation of forage, it may be worthwhile to conserve forage for a "City day".

Conclusions

Forage conservation is an avenue for ensuring continuity in ruminant feed availability. Although the nutritive qualities differ from those of fresh materials, adequate levels of nutrients are retained in conserved feed to merit use in dry periods. The requirements for additives are low and smallholders will be able to carry out the conservation on-farm provided they have sufficient access to labour. Due to their high nutrient content grass–legume mixtures are recommended.

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References

Adejumo J.O and Ademosun A.A. 1985. Effect of plant age at harvest, and of cutting time, frequency and height on the dry matter yield and nutritive value of *Gliricidia sepium* and *Cajanus cajan. J. Anim. Prod. Res.* 5(1): 1–12.

Akinola J.O. 1989. Forage Conservation and Utilization. Proceeding of Workshop on Pasture and Range Management. NAPRI, Zaria, Nigeria. pp. 101–114.

AOAC (Association of Official Analytical Chemists). 1984. Official Methods of Analysis. 14th edition, Washington, DC, USA.

Duru M. and Colombani H. 1992. Hay making: Risks and uncertainties in Central Pyreneen Grassland. *Agricultural System* 38 (2):185–207.

Ekpenyong T.E. and Onwuka C.F.I. 1987. Survey of small ruminant population and farming systems in Cross River State. In: *Browse Use and Small Ruminant Production in South East Nigeria.* Proc. Symp. of the ILCA Humid Zone Prog. May 1987. pp. 13–22.

Goering H.K. and Van Soest P.J.1970. *Forage Fibre Analyses. (Approaches, Reagents, Procedures and Some Applications).* Agriculture Handbook . No. 379. USDA, Agricultural Research Service, Washington, DC, USA. 20 pp.

Gordon E.J. 1989. Effects of silage additives and wilting on animal performance. In: Haresign W. and Cole D.J.A. (eds), *Recent Advances in Animal Nutrition.* Butterworths, London. pp. 159–173.

Henderson A.R. and McDonald P. 1977. The effect of cellulose preparation on the chemical changes during the ensilage of grass in laboratory silos. *J. Sci Food Agric.* 28:468–498.

Ikhatua U.J. and Adu LF. 1984. A comparative evaluation of the utilization of groundnut haulms and *Digitaria smutsii* hay by Red Sokoto goats. *J. Anim. Prod. Res.* 4:145–151.

McDonald 1981. *The Biochemistry of Silage.* John Wiley, New York. 266 pp.

Merchem N.R. and Satter L.D. 1983. Digestion of nitrogen by lambs fed alfalfa conserved as baled hay or as a low moisture silage. *Journal of Animal Science* 56:943–951.

Olayiwole M.B. and Olorunju S.A.S. 1986. Effect of ensilage, added nitrogen and energy on the utilization of grain sorghum stover by beef *cattle.* In*: Preston T R. and Nuwanyakpa M. Y. (eds), Towards Optimal Feeding of Agricultural Byproducts to Livestock in Africa. Workshop on Optimal Feeding of Agricultural Byproducts to Livestock in Africa, held in Alexandria, Egypt, Oct. 1985.* ILCA (International Livestock Centre for Africa), Addis Ababa. pp. 102–108.

Onifade O.S. and Akinola J.O. 1985. Effect of feeding ratio and sowing method on the production of Rhodes grass/stylo swards in the Northern Guinea savannah zone of Nigeria. J. *Anim. Prod. Res.*6:29–39.

Patterson D.C. 1990. Feeding value of finishing of silage effluent with a high initial pH. *Journal of Agricultural Science* 115(1):129–133.

Steel R.G. and Torrie J.H. 1960. *Principles and Process of Statistics.* McGraw-Hill Book Company, Washington, DC, USA. pp. 126.

Thomas P.C. 1982. Utilization of conserved forages. In: Thompson D.J., Beever De E. and Gunn R.G. (eds), Forage protein in animal production. *Brit. Soc. Anim. Prod. Occ. Publ.* No. 6. pp. 67–76.

Conservation du fourrage en vue de l'alimentation de saison sèche du bétail dans la zone humide du Nigéria

Résumé

Du fourrage de Pennisetum purpureum et des feuilles de Gliricidia sepium ont été récoltés à la fin de la saison humide et conservés sous forme de foin et d'ensilage pour alimentation du bétail des petits exploitants des zones rurales. Leur valeur nutritive a été évaluée sur une période de quatre semaines. Les foins, avec un faux d'humidité de 14 à 15%, étaient toujours fibres de toute moisissure après quatre semaines de conservation. La teneur en protéines brutes (PB) était de 5,9% pour le foin de graminées et de 14,3% pour celui de légumineuses contre respectivement 11% et 21,8% pour le matériel frais. Il y a donc eu une forte baisse du taux de protéines brutes au cours de la fenaison alors que la teneur en fibres a en revanche légèrement augmenté, passant à 37%.

L'énsilage du mélange graminées-légumineuses avait un faux d'humidité de 37%, une teneur en PB de 11% et un faux de cellulose brute de 27%, qu'il ait ou non été traite à facide formique (à 2,7 g/kg de poids frais). L'addition de maïs broyé (45 g/kg) et de mélasse (35 g/kg) améliorait la qualité de l'ensilage. Au bout de 4 semaines, le pH de l'ensilage temoin était de 4,3 contre 5,5 pour l'ensilage traité.

Etant donné la qualité du produit final, il a été recommandé de fabriquer du foin et des ensilages à partir de mélanges grami nées-légtunineuses. Les paysans devraient pouvoir utiliser eux-mêmes ces techniques de conservation à condition de disposer d'une main- d'oeuvre suffisante et d'assez de fourrage en fin de saison humide soit sur fears propres terres, soit dans la savane avoisinante.

Improving wheat straw intake by goats

J. W. W. Ng'ambi[1] *and L. Kekena-Monare*[2]

[1]National University of Lesotho, P.O. Box Roma 180, Lesotho
[2]Lesotho Agricultural College, Private Bag A4, Maseru, Lesotho

Abstract

Feed intake and digestion studies were conducted with growing goats fed diets based on wheat straw supplemented with essential nutrients. The experiment was conducted with 18 growing goats (small East African crosses) to evaluate responses in voluntary intake when molasses was sprayed on straw compared to molasses and straw fed separately. Goats ate more straw organic matter (OM) ($P<0.01$) when sprayed with molasses (0.41 kg/d) than with molasses fed separately (0.30 kg/d) or when fed on straw alone (0.30 kg/d), while OM digestibility remained unchanged. Daily digestible OM intake increased from 0.31 to 0.37 kg/d, a 19% increase ($P<0.01$).

The mean retention time of chromium mordanted straw were similar between treatments ($P>0.01$). When on *ad libitum* intake, goats on straw mixed with molasses showed larger ($P<0.01$) gut-fill values (0.90 kg OM) than when molasses was fed separately (0.72 kg OM). It is concluded that mixing straw with molasses offers a practical method of increasing the feed value of poor quality roughages. While palatability (taste and smell) may limit voluntary straw intake, gut-fill (digests load) does not appear to be a constraint to intake.

Introduction

In Zambia, ruminant animals grow rapidly during the rainy season but tend to lose weight during the dry season when they are forced to graze cereal residues which generally have low nutritive value (Smith 1986). Cereal straws are composed mainly of cell walls (about 80% of the DM) with low concentrations of cell solubles, crude protein, vitamins and minerals (Jackson 1977). When straw alone is offered ruminants digest no more than 40 to 50% of its DM (Greenhalgh 1984). Low intake and digestibility tend to limit feed value and the level of animal performance that straw can support (O'Donovan 1983).

Voluntary intake of straw may be limited by physical factors causing low rates of passage (Batch and Campling 1962). The increase in voluntary intake of chemically treated roughages has been attributed to increased digestibility and rate of passage (Berger et al 1980). However, studies by Weston and Davis (1986) indicated that low palatability may be another factor limiting voluntary intake of low quality roughages; they reported that sheep consumed 8% less straw when a supplement of Lucerne hay was provided separately than when fed in a mixture.

The objective of this experiment was to measure the responses of goats in terms of voluntary intake, digestibility and rate of passage of wheat straw sprayed with molasses as compared to straw and molasses offered separately.

Materials and methods

Eighteen growing goats (small East African crosses) of an initial weight of 18±1 kg were divided into two groups according to liveweight and within these groups the goats were randomly allocated to three treatments. The basal roughage consisted of chopped (2–10 cm long) wheat straw (variety Canary). All goats received 100 g soyabean meal, 100 g maize meal and 10 g salt per day. Treatment S was the control; SMM: 30 g liquid molasses was mixed with the straw, whereas in SMS molasses was fed separately.

The supplements were given in two equal meals at 0800 and 1500 h. The experiment consisted of three periods of 24 days with each period being composed of two parts. During the first 12 days the animals were on restricted wheat straw intake (0.3 kg) and during the second 12 days on *ad libitum* straw, when refusals were kept at 15% in excess of the previous day's intake. Goats were housed in individual pens, where water was always available.

Rates of passage of chromium-mordanted straw were measured during the last five days of each 12-day period. Voluntary intake and digestibility of feeds were measured only during the last seven days when animals were on *ad libitum* straw. Total faecal collection was used to determine digestibility. Rate of passage of digests was measured by offering to each animal 120 g chromium mordanted straw on the first day of collection at 0830 h.

Straw was mordanted with chromium as described by Berger et al (1980). The mordanted straw (particle size of 3 cm on average) was weighed and mixed with the supplements to ensure ingestion. All goats ate the mixtures rapidly and 0900 h was set as zero time. Faeces of each animal were bulked over 1200 h periods after zero time during six days dosing and weighed, thoroughly mixed and sampled for dry matter and chromium content (Mathieson and Davidson 1970).

The rate of passage of digests was calculated by the method of Castle (1956). All samples were dried at 100°C in a forced-air oven, ground (1 mm screen sieve) and then analysed for ash, nitrogen and modified acid detergent fibre (AOAC 1984). Data were analysed following the methods of Steel and Torrie (1960).

Results

The chemical composition of the feeds are shown in Table 1. Goats ate more straw mixed with molasses than when molasses was fed separately (Table 2). Intakes of straw with and without molasses were similar (49.5 and 30.3 g $kg^{0.75)}$ for total ration and straw alone rising by 22 and 33% (60.5 and 41.4 $kg^{0.75}$), respectively, when straw and molasses were mixed. Digestibility of the diets were not affected by treatment (P>0.01). Feeding straw mixed with molasses improved intake of digestible OM of the diet by 19% from 31.3 to 37.3 g $kg^{0.75}$(Table 3). Mean retention times of mordanted straw did not differ between treatments (Table 4).

Table 1. *Chemical composition of foods offered to growing goats.*

Feed (g/kg DM)	DM	CP	Ash
Wheat straw	904	38	77
Maize meal	871	94	28
Soyabean meal	992	347	62
Molasses	300	347	62

Mordanted straw*	889	41	8
S diet	892	104	63
SMM diet	894	86	64
SMS diet	892	105	63

*Mordanted straw contained 68.7 mg chromium per kg DM; S: straw without molasses; SMS: straw and molasses separately; SMM: straw mixed with molasses; CP: crude protein.

Table 2. *Intake* of *feed and mean liveweight of goats.*

	Molasses			
	None	Mixed	Alone	SED
Intake (kg/day)				
Diet DM	0.53[a]	0.65[b]	0.53[a]	0.011
Diet OM	0.49[a]	0.60[b]	0.49[a]	0.010
Straw DM	0.32[a]	0.44[b]	0.32[a]	0.010
Straw OM	0.30[a]	0.41[b]	0.30[a]	0.010
Mean liveweight (kg)	21.2[a]	21.3[a]	21.3[a]	4.26

SED: Standard error of the difference; diets see Table 1.

Within rows, values with different superscripts are significantly different (P<0.01).

Table 3. *Digestibility coefficients of the diet and digestible organic matter intake (DOMI) by growing goats.*

	Molasses			
	None	Mixed	Alone	SED
Digestibility				
Diet DM	0.60	0.59	0.60	0.013
Diet OM	0.63	0.62	0.63	0.047
Diet DOMI (kg/day)	0.31[a]	0.37[b]	0.31[a]	0.002

SED: Standard error of the difference; diets see Table 1.

Within rows, values with different superscripts are significantly different (P<p.01).

Table 4. *Mean Retention Time (MRT hours) and gut-fill (kg OM) of mordanted straw in the digestive tract of goats.*

	Molasses			
	None	Mixed	Alone	SED
MRT (restricted intake)	40.1[a]	40.1[a]	40.1[a]	2.1

MRT (*ad libitum* intake)	39.7[a]	39.6[a]	39.7[a]	2.3
Gut-fill	0.72[a]	0.90[b]	0.72[a]	0.03

SED: Standard error of the difference; diets see Table 1. Within rows, values followed with superscripts are significantly different (P<0.01).

Discussion

The protein content was above the critical value of 85 g CP per kg DM, indicating that protein content was unlikely to limit responses in intake. Since feeds were similar in chemical and physical characteristics, the hypothesis that spraying molasses on the roughage would increase voluntary intake of roughage was confirmed: intake of wheat straw increased with 37% with sprayed-on molasses without changing digestibility, corroborating the results of Weston and Davis (1986).

Goats on straw mixed with molasses were able to increase their rumen load by 25% (Table 4). This may indicate that, while rumen load plays an important role in limiting voluntary intake of low quality roughages (Balch and Campling 1962), palatability is also an important factor stimulating intake. It is concluded that mixing straw with molasses offers a practical method of increasing the feed value of poor quality wheat straw. While palatability (taste and smell) may limit voluntary straw intake, gut-fill (digesta load) does not appear to be a constraint to intake. It is concluded that spraying palatable molasses on unpalatable straw is a practical feeding system to increase the feeding value of low quality roughage such as straw.

References

AOAC (Association of Official Analytical Chemists). 1984. *Official Methods of Analysis*.14th edition. Association of Official Analytical Chemists, Washington, DC, USA.

Belch C. C. and Campling R.C. 1962. Regulation of voluntary intake in ruminants. Nutrition Abstracts and Reviews 32:669–686.

Berger L.L., Koptensein T.J. and Britton R.T.A. 1980. Effect of sodium hydroxide treatment on rate of passage and rate of ruminal fibre digestion. *Journal of Animal Science* 50:745–749.

Castle E.J. 1956. The rate of passage of foodstuffs through the alimentary tract of the goat. 1. Studies on adult animals fed on hay and concentrates. *British Journal of Nutrition* 10:15–23.

Greenhalgh J.F.D. 1984. Upgrading crop and agricultural by-products for animal production. In: Gilchrist F.M.C. and Machine R.I. (ed), *Herbivore Nutrition in the Subtropics and Tropics.* The Science Press Limited, Grenghall 2024, South Africa. pp.167–181.

Jackson M.G. 1977. Review article. The alkali treatment of straws. *Animal Feed Science and Technology* 2:105–130.

Mathieson J. and Davidson J. 1970. The automated estimation of chromic oxide. *Proceedings of Nutrition Society* 29:30A–31A.

O'Donovan P.B. 1983. Untreated straw as a livestock feed. *Nutrition Abstracts and Reviews* (B) 53:442–455.

Smith C.A. 1986. Studies on the hyparrhenia veld of Zambia. VII. The effect of cattle grazing veyld and dambo at different stocking rates. *Journal of Agricultural Science*, Cambridge 66:49–56.

Steel R.G. and Torrie J.H. 1960. *Principles and Process of Statistics*. McGraw-Hill Book Company, Washington, DC, USA. 126 pp.

Weston R.H. and Davis P. 1986. Low palatability as a constraint of the intake of wheat straw diet by sheep. *Proceedings of Nutrition Society of Australia* 11: 172–175.

Amélioration de la consommation de paille de blé chez les caprins

Résumé

Des études d'ingestion et de digestion ont été effectuées sur des caprins en croissance recevant des rations à base de paille de blé complémentées avec les éléments nutritifs essentiels. L'essai a porté sur 18 chèvres en croissance (croisements de petites chèvres d'Afrique de l'Est) pour évaluer l'ingestion volontaire lorsqu'on pulvérisait de la mélasse sur la paille ou lorsque la mélasse et la paille étaient servies séparément. Les chèvres ont consommé plus de matière organique (MO) ($P<0,01$) du mélange de paille et de mélasse (0,41kg/j) que de mélasse ou de paille servies séparément (0,3 kg/j) mais la digestibilité de la MO était restée inchangée. La consommation journalière de MO digestible a augmenté de 0,31 a 0,37 kg/j, soit une hausse de 19% ($P<0,01$).

Le temps moyen de rétention de la paille traitée au chrome était indépendent du traitement ($P>0,01$). Le contenu du boyau des chèvres nourries à volonté de paille mélangee de mélasse (0,9 kg de MO) était plus important ($P<0,01$) que celui des animaux recevant uniquement de la mélasse ou de la paille (0,72 kg de MO). Ces résultats montrent que le mélange paille-mélasse est un moyen pratique d'accroître la valeur alimentaire de fourrages grossiers de qualité médiocre. Alors que la palatabilité (goût et odeur) peut diminuer l'ingestion volontaire de paille, le contenu des boyaux ne semble pas en limiter la consommation.

Animal-Based Feed Evaluation

Comportement alimentaire et performances laitierès des chèvres sahéliennes exploitant des parcours naturels

M. Cissé, M. Awad et B. Ahokpé

Laboratoire national de l'élevage et de recherches vétérinaires

BP 2057, Dakar (Sénégal)

Résumé

22 chèvres laitières de race sahélienne ont été réparties en 2 lots conduits sur pâturage naturel pendant 8 h/j. Le lot n° 1 ne recevait pas de complémentation alors que le lot n° 2 recevait 500 g/j/animal de concentré contenant 1,17 UF et 190 g de MAD/kg de MS pendant 3 mois. Les préferences alimentaires des chèvres ont varié selon les saisons mais la teneur en matière azotée totale du régime a été relativement constante. La complémentation a eu un effet positif sur la production laitière totale ($P<0,05$) estimée à partir de la double pesée du chevreau suivie dune traite à fond de la mère. Toutefois, cet effet n'a été significatif que pendant le premier mois de complémentation.

Introduction

L' effectif caprin représente 32% du total du cheptel ruminant sénégalais. Deux génotypes différents de chèvres existent au Sénégal: la race sahélienne au nord et la race naine ou chèvre Djallonké au sud. La chèvre du Sahel est surtout utilisée pour la production laitière gérée par les femmes en milieu rural et dans les zones péri-urbaines. Cette chèvre satisfait ses besoins nutritionnels essentiellement sur les parcours naturels. L'objet du présent travail est d'étudier le comportement alimentaire et d'évaluer les performances laitières de la chèvre du Sahel, conduite sur pâturage naturel, avec ou sans complémentation.

Matériel et méthodes

Le parcours des animaux

Le site de l'étude est situé dans la zone péri-urbaine de Dakar à Sangalcam, sur une superficie de 600 ha. Dans cette zone, la saison des pluies dare 3 mois, de juillet à septembre, et la pluviométrie enregistrée en 1992 a été de 272 mm. La végétation est du type steppique. Les sots sont sableux et argilosableux et le relief comporte des bas-fonds humides au niveau des dépressions interdunaires.

Les chèvres et leur conduite

22 chèvres sahéliennes âgees de 2 ans en moyenne et ayant mis-bas pendant la période de juillet à décembre 1992, suite à une synchronisation des chaleurs (Cissé *et al*., 1992), ont fait l'objet de cette étude. A partir du 14ᵉ jour de lactation, les chèvres ont été réparties, de façon

aléatoire et alternativement, en 2 lots nutritionnels conduits sur pâturage naturel pendant 8 h/j. Le lot n° 1 ne recevait pas de complémentation. Le lot n° 2 recevait le soir, au retour du pâturage, 500 g/j/animal de concentré (66% de maïs, 30% de tourteau d'arachide, 1% de CMV) de teneur calculée en énergie et en protéines de 1,17 UF et 190 g de MAD/kg de MS, respectivement. La compleméntation a duré 3 mois.

Prélèvement et mesures

Activités au pâturage et description du régime

Pendant l'hivernage, les chèvres consommaient surtout les repousses de graminées cultivées de la ferme. Pendant la saison sèche, la composante ligneuse qui constituait l'essentiel de leur régime a été étudiée selon trois transects définis sur les différents itinéraires suivis quotidiennement par les animaux et le berger. Le comportement au pâturage a été étudié tous les 15 jours à partir du mois de mars. Au cours de chaque séance, l'activité des chèvres en terme de temps consacré à la pâture, à la rumination, à la marche, à l'abreuvement et au repos, a été enregistrée toutes les 15 minutes. Le régime a été caractérisé par la méthode de "collecte du berger" ou l'expérimentateur dénombre les contacts "bouche animale-espèce végétate", prélève et identifie les espèces consommées en imitant les bouchées de l'animal au pâturage (Guérin *et* al., 1988).

L'échantillon végetal collecté a été immédiatement séché à l'etuve à 105 °C pour la détermination de la matière sèche et l'analyse chimique.

Contrôle laitier

Le contrôle laitier s'est effectué une fois par semaine par la méthode de la double pesée du chevreau avant et après la têtée, suivie dune traite à fond de la mamelle au tours de 4 têtées consécutives à 8, 13, 18 et 22 heures. Les chevreaux étaient séparés des mères à la veille du contrôle laitier. Les pesées des chevreaux et du lait trait s'effectuaient avec une balance de 0,1 g de précision. Un échantillon de lait était constitué à chaque contrôle à partir des traites du matin et de celles de 18 heures. II était conservé à 4 °C jusqu'à (analyse, après addition de 1 ml de formol pour 100 ml de lait.

Analyses

La matière azotée du fait et de f échantillon végétal a été déterminée par la méthode de Kjeldahl. Le lactose du lait a été dosé par la méthode de Bertrand et le faux butyreux par la méthode de Gerber (Journal officiel, 1954).

Les chiffres de production laitière ont été calculés selon un modèle d'analyse de variance-covariance, incluant les facteurs complémentation, saison de mise-bas, age de la mère et faille de la portée. Pour chaque variable, les mesures effectuées pendant les deux premierès semaines de lactation où la conduite était identique pour les lots ont servi de covariables.

Résultats et discussion

Sur une duree totale d'observation de 96 heures, 88,6% du temps ont été consacrés à l'ingestion, 4,7% au déplacement sans ingestion, 3,8% à l'abreuvement, 1,7% au repos et 1,2%

a la rumination en position debout ou couchée. Le temps consacré à l'ingestion a eu tendance à être plus long pendant la saison sèche (80,6 à 92,2%) que pendant la saison des pluies (77,1 à 89,7%). En particulier, aux mois d'août et de septembre, les chèvres ne commençaient à ingérer qu'à partir de 11 heures, après la disparition de l'humidité sur les feuilles. La composition floristique du pâturage (tableau 1) a déterminé le choix des animaux mais la composition du régime n'a pas toujours reflété celle du pâturage car, toutes les espèces n'étaient pas consommées (par exemple *Chysobalanus orbicularis)* et certaines étaient plus appétées que d'autres (par exemple *Acacia albida*). Les préférences alimentaires ont varié au cours des saisons. La part des ligneux dans le régime s'est accrue dès la saison des pluies (figure 1). De 14% au mois d'octobre, elle a connu deux pits (juillet et janvier), puffs a diminué sans pour autant s'annuler au mois de septembre (4%) où l'on a enregistré le pit de consommation d'espèces herbacées. La teneur en matière azotée totale (MAT) des herbacées est faible en saison sèche (50 à 100 g/kg de MS, Guérin *et al.,* 1988), mais en raison de la forte consommation de ligneux, la MAT du régime des chèvres a été en moyenne de 141±29 g/kg de MS et n'a pas présénté de variation saisonnière importante. Néanmoins, compte tenu de la présence de substances antinutritives comme le tanin (Le Houérou, 1980) en proportions non déterminées sur les espèces ligneuses consommées, certains aspects relatifs à leur valeur nutritive restent à préciser.

Tableau 1. *Végétation ligneuse du parcours. Contribution des espèces (en %) et densité du peuplement (en nombre de sujets/ha).*

	Transects		
Espèces	Nord	Sud	Est
Crateva religiosa	31,5*	–	22,5*
Maytenus senegalensis	21,2*	33,5*	9,0*
Acacia albida	11,5*	28,5*	14,3*
Piliostigma reticulata	6,8	6,3	4,6*
Parinari macrophyla	6,2	8,3*	25,3*
Grewia bicolor	5,2	0,5	–
Annona senegalensis	4,1	–	0,6
Dichrostachys cinerea	3,5	5,0	5,8
Detarium microcarpum	2,8	–	0,3
Euphorbian balsamifera	2,4	2,4	2,3
Ficus gnafalocarpus	2,4	0,5	1,3
Commiphora africana	0,6	0,6	1,0
Adansonia digitata	0,6	–	–
Ziziphus mucronata	0,6	0,5	0,3
Ficus toningui	0,6	0,5	–
Ziziphus mauritiana	0,7	0,3	–
Azadirachta indica	–	–	1,3
Dialium guineensis	–	–	0,3
Balanites aegyptiaca	–	–	3,0
Landolphia perotetti	–	–	1,0

Capparis tomentosa	–	2,8	0,3
Chysobalanus orbicularis	–	0,6	1,3
Anacardium occidentale	–	0,5	–
Combretum lecardi	–	7,8	3,2
Lanea velutina	–	–	2,0
Densité	147	157	164

*Trois espèces omman es sur le 3 transects definis selon le parcours des chèvres.

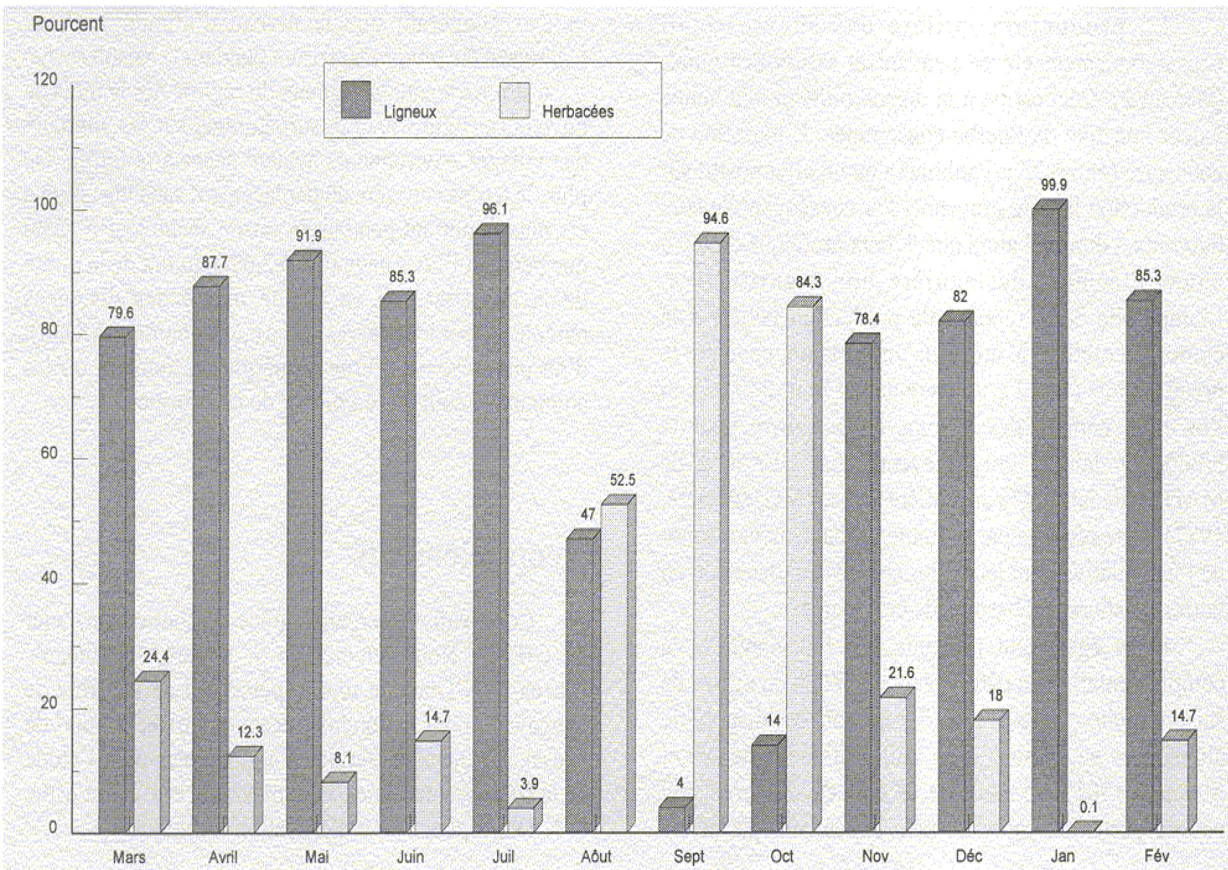

Figure 1*. Composition botanigue du regime des chevres.*

La production laitière des chèvres était considérablement élevée pendant la saison des pluies (tableau 2). Ceci. est lié à la disponibilité et à la bonne valeur nutritive de l'herbe consommée. L'ingestion de concentré (456 ± 25 g/j/animal) a eu un effet positif sur la production laitière moyenne. Par conséquent, le taux butyreux a diminué alors que le taux protéique du lait a augmenté mais de manière non significative. L'amplitude de la réponse de production laitière à la complémentation a été plus importante pendant le premier mois (180,2 g/j/chèvre de fait brut, P<0,05). Si l'on tient compte des besoins de la chèvre pour la production laitière qui s'élèvent à 0,4 UF, 50 g de MAD/kg de lait et 4% de matière grasse (MG) (Rivière, 1977), cette réponse paraît faible probablement à cause de l'âge relativement jeune des chèvres qui devaient, en outre, satisfaire des besoins de croissance.

Tableau 2. *Quantité de fait produite par les chèvres (en g/kg) et composition du fait (en g/kg).*

	Sources de variation [2]					
	Moyenne[1]	apport complément	saison de mise-bas	âge	taille	RSD[3]
Semaines 3 à 6						
Laittotal[5]	1037,3	180,2+	245,2+	147,6ns	86,1 ns	169,9
Laitconsommé	602,1	98,8ns	–242,2+	312,2+	371**	130,4
Lait trait	451,9	26,0ns	81,2ns	–81,6ns	142,6ns	188,9
Taux butyreux	36,4	–4,2ns			2,0ns	7,3
Taux protéique	43,8	5,6ns			4,6ns	8,7
Taux de lactose	41,0	0,2ns			8,8ns	8,9
Semaines 3 à 10[4]						
Laittotal[5]	940,6	168,6ns	174,8ns	29,2ns	162,6ns	206,1
Lait consommé	568,7	106,6ns	–176,5ns	262,6ns	337,3*	147,8
Lait trait	399,3	11,9ns	102,6ns	–34,0ns	118,3ns	176,6
Taux butyreux	37,5	–3,2ns			3,5ns	7,1
Tauxprotéique	48,7	5,lns			2,1ns	5,5
Taux de lactose	40,5	2,6ns			6,8+	6,2
Semaines 3 à 14[4]						
Lait total[5]	805,3	100,6ns	172,5ns	66,8ns	121,5ns	221,7
Lait consommé	520,3	52,2ns	–102,4ns	153,7ns	294,8*	131,4
Lait trait	329,3	246,6ns	89,2ns	–19,4ns	75,6ns	149,2
Taux butyreux	37,0	–2,8ns			3,6ns	7,1
Taux protéique	49,2	4,2ns			1,8ns	5,2
Taux de lactose	38,8	0,3ns			7,8+	5,7

1.Moyenne ajusté

2 Sources de variation : effet des facteurs respectifs constitue la différence (complémenté-non complémenté),(saison des pluies-saison sèche), (âgé de plus d'un an-âgé d'un an), (portéeu multiple-simple portée). Il est significatif à 1% **, 5% * , 10%+, ou non significatif (ns).

3 Ecart-type résiduel

4 Période de complémentation : l[er] mois (semaines 3 à 6 de lactation), 2 premiers mois (semaines 3 à 10) et période totale (semaines 3 à 14);

5 Effet de la covariable significatif à p< 0,01.

Il est également probable que l'avantage de la complémentation au pâturage ait été réduit en milieu de saison sèche, suite à une diminution du disponible alimentaire en dessous d'un seuil critique (Chenost et Molenat, 1981). La méthode de collecte du berger n'a pas de prétention quantitative. Cependant, parmi les indices suggérant que le niveau d'alimentation au pâturage a été plutôt insuffisant pendant la saison sèche, il y a la forte teneur en ligneux du régime dès le mois de novembre (figure 1) et le surpâturage, car les animaux des villages environnants avaient accès a la ferme. De plus, le temps consacré au déplacement sans ingestion a été plus important pendant la saison sèche (5,1 à 15%) que pendant l'hivernage (0,6 à 2,6%) du fait de la rareté de la nourriture. Il en est de même des distances parcourues par les chèvres (4,5 à 6,5 km contre 2 à 3 km), d'où une dépense accrue d'énergie au moment où les animaux ne sont pas au mieux de leur forme.

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Bibliographie

Chenost M. et Molenat G. 1981. Influence de la complémentation sur la quantité d'herbe ingérée par l'animal au pâturage, du 14 au 18 septembre 1981. INRA (Institut national de la recherche agronomique), Théix (France).

Cissé M., M'Baye M., Sané L, Corréa A. et N'Diaye I. 1992. Rapport entre les variations saisonnières de l'état corporel et les performances de reproduction de la chrèvre du Sahel au Sénégal. Communication présentée à la deuxième Conférence biennale du Réseau africain de recherche sur les petits ruminants, du 7 au 11 décembre 1992. Arusha (Tanzanie).

Guérin H., Friot D., M'Baye M., Richard D. et Dieng A. 1988. Régime alimentaire des ruminants domestiques (bovins, ovins, caprins) exploitant des parcours naturels sahéliens et soudano-sahéliens. 2. Essais de description du régime par l'étude du comportement alimentaire. Facteurs de variation des choix alimentaires et conséquences nutritionnelles. *Revue d'élevage et de médecine vétérinaire des pays tropicaux* 41(4): 427–440.

Journal officiel. 1954. Analyse physique et chimique du lait. Méthodes officielles. Imprimerie des journaux, Paris (France). 33 p.

Le Houérou H.N. 1980. Le rôle des ligneux dans la gestion des parcours. *In : Les fourrages ligneux en Afrique, état actuel des connaissances.* Publié sous la direction de H.N. Le Houérou. Actes du colloque sur les fourrages ligneux en Afrique, Addis Abeba (Ethiopie), du 8 au 12 avril 1980. CIPEA (Centre international pour l'élevage en Afrique), Addis Abeba (Ethiopie). p. 329 à 338.

Rivière R. 1977. Manuel d'alimentation des ruminants en milieu tropical. Manuels et précis d'élevage n° 9. Ministère de la Cooperation/IEMVT (Institut d'élevage et de médecine vétérinaire des pays tropicaux), Maisons-Alfort (France). 521 p.

Grazing behaviour and performance of Sahelian goats on natural pastures

Abstract

Twenty-two lactating Sahelian does were allocated to two groups grazing on natural pastures for 8 h/day. The first group was not supplemented while the second group received for three months a supplement of 500 g/day/animal of concentrates containing 1.17 feed units and 190 g of digestible N/kg DM. Diets selection by the goats varied with seasons but their total nitrogen content was relatively constant. Supplemented does gave significantly higher milk yield ($P<0.05$) estimated by kid weighing followed by a thorough milking of the mother.

The difference was, however, significant only during the first month of supplementation.

An evaluation of browse forage preferences by sheep and goats in the Northern Guinea Savannah zone, Ghana

N. Karbo[1], P. Barnes[2] and H. Rudat[3]

[1]Animal Research Institute, Box 52, Nyankpala, Ghana
[2]Animal Research Institute, Box 20, Achomota, Ghana
[3]Crops Research Institute (NAES), Box 52, Nyankpala, Ghana

Abstract

Fourteen Djallonke sheep and six West African Dwarf goats were used in cafeteria style trials to study their preference to four freshly cut browses species viz, *Leucaena leucocephala, Gliricidia sepium, Cajanus cajan* and *Sesbania sesban* which were grown on Crops Research Station (NAES) at Nyankpala in Ghana.

Forage preference of sheep was: *Cajanus* > *Leucaena* > *Sesbania* > *Gliricidia,* while that of dwarf goats was: *Leucaena* > *Cajanus* > *Sesbania* > *Gliricidia. Gliricidia* was not consumed at all, even when fed alone to sheep or goats. Sheep preferred *Cajanus* and hardly touched *Leucaena* or *Sesbania;* in contrast, 75–85% of the goat intake consisted of *Leucaena* followed by *Cajanus* (15–29%) and *Sesbania* (0–5%). These findings were discussed in relation to differences in ingestive behaviour of sheep and goats and chemical composition of the forages.

Introduction

In the northern savannah zone of Ghana where due to both biotic and abiotic factors, land degradation has become severe, promoting integrated crop–livestock production aimed at improving soil fertility and sustaining productivity is of utmost importance. Agroforestry through alley farming with woody plant species (e.g. *Butyrospermum parkii, Acacia albida, Leucaena leucocephala, Gliricidia sepium* etc) have been widely suggested for similar zones (Young 1989). Furthermore, some of these species can provide forage for ruminant livestock as well as fuel wood for household use (Okafor and Fernandes 1987).

Adequate information on preferences of browse species by sheep and goats in this ecological zone is lacking. For successful integrated tree–crop–livestock farming systems, the assessment of forage preferences of ruminants could enhance the efficient utilisation of farm land for food and cash crops, and for fodder production for livestock.

This study evaluated the relative acceptability of *Leucaena leucocephala, Gliricidia sepium, Cajanus cajan* and *Sesbania sesban* as forage for sheep and goats. These woody species have been recommended for alley cropping in farming systems of the savannah zone (Rudat and Frey 1990, Schmidt and Frey 1992).

Materials and methods

In November 1992, trials were earned out with 14 sheep and 6 goats to evaluate their preference for forages from *Leucaena leucocephala, Gliricidia sepium, Cajanus cajan* and *Sesbania sesban*grown in alley rows at the Animal Research Institute in Nyankpala.

Two types of experiments were carried out. In the first set, eight young Djallonke sheep were housed in individual pens. Freshly cut forages of *L. leucocephala, S. sesban* and C. *cajan* were offered in a cafeteria type of experiment. The forages were loosely tied in bundles of known weight and placed within equidistant reach from the animal. The time spent sniffing or eating forage species was monitored over a period of 15 minutes using a stop watch. Forages were then left in the pens for 2–3 hours and weighed in order to determine intake. Coefficient of preference (COP) which is the ratio between the intake of each forage divided by the total intake was used in determining forage preferences. A forage type was said to be preferred by animals to the others when the calculated COP is more than unity. This trial was repeated, but instead of *Sesbania sesban, Gliricidia sepium* was fed. In a third trial, *G. sepium* was fed alone to confirm its rejection by sheep.

In a second feeding experiment, two separate groups of six adult sheep and goats were used. The three forages of known weights were placed in heaps in an enclosed yard into which animals were released. The number seen eating each forage source was recorded every minute over a 15-minute period. Forage intake by group was also monitored. As in the first experiment, two sets of forages were compared by replacing *Sesbania* with *Gliricidia.*

Animals had free access to water and were not starved before the start of each experiment. Samples of the forages were taken, dried and analysed for crude protein and mineral levels using the Kjeldahl and Atomic Absorption Spectrophotometer (AAS), respectively.

Results

In the first trial with individually fed sheep, *Cajanus* was eaten most, despite much sniffing of *Leucaena* and *Sesbania.* Thereafter, sheep broadened their diet to the other species eating a total of almost 0.5 kg DM/head (Table 1). In the second trial, they confirmed their first choice, hardly touching *Leucaena* and ignoring *Gliricidia.* Their intake declined to 0.2 kg/head (Table 2). When *Gliricidia*was offered alone, sheep confirmed their earlier preferences by complete refusal.

Table 1. *Eating behaviour and average forage intake by sheep individually fed* C. cajan, L. leucocephala *and* S. sesban.

Index	Forage source		
	Cajanus	*Leucaena*	*Sesbania*
Forage offered, g/head	1000	1000	1000
Behaviour, mins:			
– time spent sniffing	0.5	1.5	2.0
– time spent eating	6.5	0.6	0.0
Average forage intake over 3 hours, g/head	225	150	112
Coefficient of preference	1.38	0.92	0.69

(COP)			

Table 2. *Eating behaviour and average forage intake by sheep individually fed* C. cajan, L. leucocephala and S. sesban.

Index	Forage source		
	Cajanus	*Leucaena*	*Gliricidia*
Quantity of forage offered, g/head	800	800	800
Behaviour, mins:			
– time spent sniffing	0.5	0.0	0.5
– time spent eating	9.8	0.9	0.0
Average forage intake over 3 hours, g/head	193	12	0.0
Coefficient of preference (COP)	2.81	0.18	0.0

The group feeding experiments are summarised in Table 3. As little feed was on offer, the sheep showed that *Cajanus* was their first choice as they virtually ignored the other two species; perhaps if given more time and feed they may have changed and eaten some *Leucaena* and *Sesbania.* The goats were less conservative, although preferring *Leucaena,* they tried *Cajanus* and some *Sesbania.*Again, both sheep and goats rejected *Gliricidia.*

Table 3. *Diet selection* (196) *and total intake by groups* of *five sheep or six goats when exposed to three forages for IS minutes.*

Diet composition (%)	Sheep		Goats	
Ca/anus	100	98	20	15
Leucaena	0	2	75	85
Sesbania	0	–	5	–
Gliricidia	–	0	–	0
Total intake, g/head	75	340	200	240
Eating, % of time	40	70	23	43

Intake and time spent eating were variable. Sheep being timid ate little of the first batch (75 g/head), but relished *Cajanus* in the second trial. Goats being browsers spent less time eating and consumed more per unit time than sheep.

Discussion

The ability to select palatable forage was demonstrated from how the experimental sheep and goats reacted to the offered legume forages. Most probably, due to animal species difference, *Cajanus cajan* was preferred by sheep and *Leucaena leucocephala* by goats. As shown by Demarquilly (1980), goats have catholic taste from sweet to bitter and select from a wider range of species.

It is generally known that ruminants on pasture tend to selectively graze plants that contain a high level of crude protein. This may partly explain the preference by sheep of *Cajanus* which the highest level of crude protein (26.3%). However, goats preferred *Leucaena,* which had the lowest CP content.

Gliricidia sepium is known to have a great potential in soil fertility maintenance as well as providing forage for feeding to livestock. However, available reports on the intake of this legume have been contradictory. In cattle feeding experiment, where *Gliricidia* was offered at 1.2 kg/head/day as a supplement to cocoa-pod based diet, the consumption of *Gliricidia* was only 0.2/kg/head/day (Smith 1987). Earlier, Mahadevan (1956), reported that cattle did not relish *Gliricidia.* However, Vearaslip (1981) and Chadhokar (1982) reported high intakes by ruminants. Our findings indicate refusal, probably because *Gliricidia sepium* appears to be new forage to animals in the zone, as it was introduced later than the other legume forages.

Gliricidia leaves have characteristic smell which may make it unattractive to ruminants. Furthermore, the presence of a potential toxic substance called coumarin (Spore 1992) which changes to dicoumerol when the leaves are crushed, could also contribute to its rejection. Dicoumerol is actually responsible for antinutritional effect and is known to interfere with the normal blood clotting induced by vitamin K.

The difference in the behaviour of sheep and goats in the group feeding trials may have affected animal counts per minute and the resulting eating time. Fighting and aggressive behaviour at feeding was observed with goats and not with sheep. However, the shorter feeding time of goats did not affect their intake. Due to the bullying behaviour by the stronger goats, animals constantly moved between forage sites in order to avoid being beaten. Hence, group feeding animals may not be suitable for goats.

Conclusions

When offered forage of *Leucaena leucocephala, Cajanus cajan, Sesbania sesban* or *Gliricidia sepium,* Djallonke sheep will eat *Cajanus cajan* as first choice, whereas West African Dwarf goats prefer*Leucaena leucocephala* to *Cajanus cajan* and *Sesbania sesban* or *Gliricidia sepium.* The last was rejected by sheep and goats.

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References

Chadhokar P.T. *1982. Gliricidia maculata — A* promising fodder plant *World Animal Review* 44:36–43*.*

Demarquilly C. 1980*.* Taste qualities of feeds for ruminant animals. In: *Palatability and Flavour Use in Animal Feeds. First International Symposium on Palatability and Flavour Use in Animal Feeds, 10–11 Oct. 1978, Zurich, Switzerland.* Verlag Paul Parey, Hamburg und Berlin.

Mahadevan V. *1956.* Nutritive value of green manure crops. *2 Gliricidia maculata. India Vet.* J. 32:457–462*.*

Okafor *J.C.* and Fernandes E.C.M. *1987.* Compound farms of southeastern Nigeria. A predominant agroforestry home–garden system with crops and small livestock. *Agroforestry System* 5:153–168.

Rudat H. and Frey E. 1992. Agroforestry experiments with local and non-local tree species. Agronomy on station (Programme 11). NAES Annual In-House Review, 3–5 March 1992*.*

Schmidt G. and Frey E. 1982. Cropping systems research at Nyankpala Agricultural Experiment Station. Nyankpala Agric. Research Report (8), 1992*.*

Smith O.B. 1987*.* Effect of forage supplementation and alkali treatment of cocoa pod on the utilization of cocoa pod based diets by ruminants. In: *Isotope Aided Studies on Non-protein Nitrogen and Agro-Industrial By-products Utilization by Ruminants. Proceedings of Final Res. Co-ord. Meeting, Vienna, 24–26 March 1988* IAEA (International Atomic Energy Agency), Vienna, Austria. *pp.* 157–169.

Spore *1992.* Toxins from *Gliricidia.* By-monthly Bulletin of the Technical Centre for Agric. and Rural Cooperation (CTA), No. *39,* June 1992. p.10*.*

Vearaslip T. 1981. Digestibility of rice straw ration as supplemented with *Leucaena leucocephala* and *Gliricidia maculata. Thai J. Agric. Sci.* 14:256–264*.*

Wilson G.F., Kang B.T. and Mulogey K. *1986.* Alley cropping: Trees as sources of green manure and mulch in the tropics. *Biological Agriculture and Horticulture* 3:251–267*.*

Young A. *1989. Agroforestry for Soil Conservation.* C.A.B. International. International Council for Research in Agroforestry (ICRAF), UK. 276 pp*.*

Evaluation des préférences des ovins et caprins en matière de fourrages ligneux daps la partie septentrionale de la savane guinéenne au Ghana

Résumé

Quatorze moutons Djallonké et six chèvres naines d'Afrique occidentale ont été utilisés dans plusieurs essais d'alimentation à l'auge destinés à étudier leurs préférences entre les fourrages frais de*Leucaena leucocephala, Gliricidia sepium, Cajanus cajan* et *Sesbania sesban,* arbustes fourragers plantés à la Crops Research Station (NAES) de Nyankpala (Ghana).

Les ovins préféraient *Cajanus, Leucaena, Sesbania, Gliricidia* dans cet ordre, alors que la préférence des caprins allait à *Leucaena, Cajanus, Sesbania, Gliricidia, é*galement dans cet ordre. Ni les ovins, ni les caprins ne consommaient du fourrage de *Gliricidia,* même lorsqu'il leur était présenté seul. Les ovins préféraient *Cajanus* et ont à peine touché *Leucaena ou Sesbania. A* l'inverse, 75 à 85 % de la consommation des chèvres était du *Leucaena, suivi* du *Cajanus (15 à 29%)* et du *Sesbania (0 à 5%).* Ces observations ont été interprétées en fonction des

différences entre le comportement alimentaire des ovins et des caprins et de la composition chimique des fourrages.

The value of *Acacia brevispica* and *Leucaena leucocephala* seedpods as a dry season supplement for calves in arid areas ofKenya

E. M. Nyambati[1], C.N. Karue[2] and N.K.R. Musimba[2]

[1]Kenya Agricultural Research Institute, P. O. Box 450 Kitale
[2]Faculty of Agriculture, University of Nairobi, P.O. Box 30197, Nairobi

Abstract

Two feeding experiments were conducted to evaluate the nutritive value of *Acacia brevispica* and *Leucaena leucocephala* seedpods in terms of chemical composition and liveweight performance. In feeding experiment one (FE-1), 18 calves weighing on average 132 kg and aged five to nine months were used. The treatments comprised of A_1: control-1, B: *Acacia* seedpod meal (ASM) and C_1*: Leucaena* seedpod meal (LSM-1). In feeding experiment two (FE-2), 16 calves weighing on average 131 kg and aged five and half to nine months were used. The treatments were A_2: control-2 andC_2*:* LSM-$_2$.

Experimental diets were designed to supply isonitrogenous levels of 265 g CP to meet the CP requirement for a predetermined performance goal of 500 g/d. Control calves were given basal hay and wheat bran equivalent to the amount used in formulating ASM and LSM diets. Calves were weighed weekly over five and four weeks in FE-1 and FE-2, respectively. F-test was used to compare experimental groups with the controls.

Chemical analyses of seedpods of A. *brevispica* and *L. leucocephala* showed that contents of CP decline and fibre (NDF and ADF) increase with maturity. Seeds of both *A. brevispica* and *L. leucocephala* contained higher CP, EE and IVDMD, but lower fibre than empty pods. Dry *L. leucocephala* seedpods contained appreciably more tannins than *A. brevispica*. More of the tannins were located in the empty pods.

In FE-1, ADG (g/d) was 486, 250 and 239 for calves on LSM-1, ASM and Control-1, respectively. Calves supplemented with LSM-1 diet had better ADG (P<0.01) than control-1 and ASM supplemented calves. Calves on ASM had superior ADG than control-1, though not significantly (P>0.05). In FE-2, calves on LSM-2 had significantly higher (P<0.01) ADG (559 g/d) than control-2 (276 g/d) confirming the results obtained in FE-1. Intact seedpods of both legume trees had similar digestible energy (DE) contents. However, seedpods of *A. brevispica* used in FE-1 contained only 65% of their seeds and thus had lower contents of DE. The ADG of calves on ASM diet did not reflect the true nutritive value of intact seedpods.

It was concluded that if most seeds are retained, both seedpods are suitable feeds for ruminants, at least for strategic supplementation by smallholder farmers and agro-pastoralists when other feeds are unavailable in the dry season.

Introduction

Livestock productivity in sub-Saharan Africa remains low. Nutrition is one of the major constraints to cattle production in the tropics, particularly the lack of protein during the dry season (Karue 1974; FAO 1981; Minson 1990). In developing countries, conventional supplements such as oilseed cakes and animal by-product meals are rarely used because they are expensive and not readily available. Under these circumstances, the most practical supplement would be to use feed resources from locally available legume trees. *Acacia,* a genus of indigenous woody legumes occupy a dominant position in plant communities in semi-arid and arid areas of tropical and subtropical countries (NRC 1979). Studies have indicated that seedpods of some *Acacia* species such as *A. tortilis* and *A. albida* as well as leaves of *A. brevispica* when offered as supplements to poor-quality roughages*,* give liveweight gains comparable with those of livestock fed oilseed cakes and lucern *(Medicago sativa*) (ILCA 1988, 1989; Tanner et al 1990).

Leucaena leucocephala is a versatile drought tolerant tree legume and studies have demonstrated that *Leucaena* forage when fed as a supplement to roughages, supports liveweight gains comparable to those derived from conventional supplements such as oilseed cakes (Thomas and Addy 1977), animal by-product meals (Siebert et al 1976) and cereal by-product meals (Saucedo et al 1980; Manidool 1983). Chemical analysis of *L. leucocephala* seedpods in Nigeria (Adeneye 1979) and India (Damothiran and Chandrasekaran 1982) revealed that they are of high nutritive value indicating the possibility of utilising them as a source of cattle feed. Naseeven et al (1989) indicated that cracked *L. leucocephala* seeds are as good a protein source for fattening cattle as cottonseed cake. Both tree legumes are prolific producers of seedpods which can be harvested and fed to cattle. The current study evaluated the seedpods as a dry season supplement for smallholder farmers and agro-pastoralists when other feeds are unavailable.

Materials and methods

Experimental animals

Two feeding experiments were conducted at the University of Nairobi field station, Kabete, Kenya using Boran crossbred calves. In feeding experiment 1 (FE-1) 18 calves aged between five and nine months and weighing an average of 132 kg (91 to 150 kg) were used. The calves were assigned to three treatment groups balanced for age, initial liveweight and sex. The treatments were: A_1:control-1; B: *Acacia* seedpod meal (ASM) diet; and C_1: *Leucaena* seedpod meal (LSM-1) diet. In feeding experiment two (FE-2), 16 calves aged between five to nine months and weighing an average of 131 kg (102 to 162 kg) were used. The calves were assigned to two balanced treatment groups: A_2: control-2 and C_2: LSM-2 diet.

Experimental feeds

Rhodes grass *(Chloris gayana)* and Maasai love-grass *(Eragrostis superba)* hays were used as basal diet in FE-1 and FE-2, respectively. Both hays were chaffed into approximately 5-10 cm pieces to facilitate handling and feeding. Dry seedpods of A. *brevispica* and *L. leucocephala* were collected, sun-dried for two to three days before they were ground into a meal. Approximately 65% of *A.brevispica* seedpods collected contained seeds. Most of the *L. leucocephala* seedpods collected contained all the seeds.

Experimental procedures

Calves were confined in individual pens throughout the experimental period. All calves were dewormed using valbazen and sprayed against ectoparasites using stelladone. Fourteen days were allowed as adjustment periods in both feeding experiments. The experimental diets (treatments B and C) were formulated using a legume seedpod meal, wheat bran and a mineral mixture in proportions designed to supply isonitrogenous levels. A daily intake (air dry weight) of 1.5 kg of diet B (ASM) and 1.2 kg of diet C (LSM) and at least 2.5 kg of basal hay would supply 60% (265 g CP) of the total CP requirement for a growth rate of 0.5 kg/d in calves of about 150 kg liveweight (NRC 1976). The control animals were offered 0.6 kg of wheat bran (diet A) equivalent to the amount used in formulating diet B and C. Supplemental diets were offered in the morning (0500 h). All calves were individually offered a basal diet of grass hay *ad libitum* between 0600 and 1430 h.

Calves were watered once a day (0915 to 1000 h) when *ad libitum* water was offered. Daily records of hay and supplement offered and orts were kept. Calves were weighed weekly on a weighbridge in the morning when they had been without food and water overnight for approximately 13 hours. FE-1 and FE-2 were conducted for five and four weeks, respectively.

Chemical and statistical analyses

Chemical analyses were carried out on seedpods at four phenological stages to monitor nutrient profiles with maturity and on separated seedpod components to determine the contribution made by seed and the empty pods (carpets) to the nutritive value of the whole seedpod. Chemical analyses were determined following conventional methods (Van Soest 1963; Tilley and Terry 1963; Burns 1963, 1971; AOAC 1980). Weekly liveweights of individual animals were adjusted using covariance analysis based on initial liveweights (SAS 1987). Computed average daily weight gain and grass hay intake data were subjected to one-way analysis of variance and treatment means separated using Duncan's multiple range test (Steel and Torrie 1980).

Results

Chemical analysis

Contents of CP, Ash, NDF and ADF in A. *brevispica* and *L. leucocephala* pods at four phenological stages are presented in Table 1. For both seedpods the contents of CP declined while that of fibre (NDF and ADF) increased with maturity. There was no consistent trend in the total ash in both seedpods. However, the levels did not fluctuate much with age. Nutrient composition of separated dry seedpod components of both A. *brevispica* and *L. leucocephala* are presented in Table 2. Seeds of both seedpods contained more CP, EE and were more *in vitro* digestible, but had lower fibre and total ash contents than empty pods (carpels). Seedpods of *L. leucocephala* had higher tannin contents than *A*. *brevispica,* more of which were located in empty pods.

Table 1. *Contents of CP, Ash, NDF and ADF in L.* leucocephala *and* A. Brevispica *seedpods at four phenological stages.*

Stage of growth	%DM			ADF
	CP	Ash	NDF	
A. brevispica				

Immature (5)[a]	18.6	4.4	42.3	36.1
Dough (9)	18.4	5.0	49.0	36.6
Mature (13)	17.8	4.5	5.09	34.2
Dry (15)	14.3	4.1	55.0	33.5
L. leucocephala				
Immature (5)	27.2	5.4	29.2	20.0
Dough (9)	2.08	5.5	46.8	34.4
Mature (13)	2.03	5.09	53.3	42.2
Dry (15)	18.6	5.7	56.1	42.1

a Number in parentheses denotes age in weeks after pod formation.

Table 2. *Contents of CP, Ash, EE, NDF, ADF, IVDMD, DE and Tannin content of separated dry seedpod components of* Leucaena leucocephala *and* Acacia brevispica.

	Whole pods		Empty pods		Seeds	
	Leucaena	*Acacia*	*Leucaena*	*Acacia*	*Leucaena*	*Acacia*
CP	18.6	14.3	5.7	8.5	28.2	18.6
Ash	5.7	4.1	7.8	5.1	4.2	3.3
EE	4.4	3.8	2.3	2.2	9.1	4.2
NDF	56.1	55.0	73.7	78.5	41.3	30.7
ADF	42.1	33.5	62.0	58.1	19.3	16.0
IVDMD %	53	54.7	21.2	21.5	72.6	80.9
DE[a] (Kcal/g DM)	2.409	2.504	0.628	0.645	3.507	3.971
Tanning content (%)[bc]	1.76	0.09	2.03	0.18	1.55	005

a Estimated using regression equation, Y = –0.559 + 0.056X ; r = 0.966 and SE = 0.083 (Heaney and Pigden 1963) where X = digestible organic matter in g/100 g DM.

b Expressed as catechin equivalent.

c Standard curve given in Appendix 2.

Nutrient composition of feed ingredients, experimental diets and hay used in FE-l and FE-2 is given in Table 3. LSM and the formulated LSM diet had higher total ash, lower fibre, higher *in vitro*digestible and more estimated digestible energy (DE) than ASM and the formulated ASM diet, respectively. LSM-2 used in FE-2 had lower CP, higher fibre and lower *in vitro* dry matter digestibility than LSM-1. Both hays used in FE-1 and FE-2 contained similar contents of CP, ash, and fibre except for *in vitro* dry matter digestibility which in FE-2 hay was higher.

Table 3. *Nutrition composition* of *feed ingredients, experimental diets and hay used in FE-I and FE-2.*

	%DM	DE (Kcal/g

	DM	CP	Ash	NDF	ADF	IVDMD	
FE-1							
Acacia seedpod meal	89.1	12.1	4.9	63.7	49.0	40.0	1.681
Leucaena seedpod meal-1	89.9	17.7	5.5	52.7	38.6	54.8	2.510
Wheat bran-1	88.9	16.0	6.9	53.5	16.4	72.5	3.501
Diet A1 (control-1)	92.3	15.6	8.3	50.5	15.6	75.4	3.663
Diet B (ASM)	91.8	14.0	6.5	59.0	32.6	56.0	2.577
Diet C1 (LSM-1)	92.1	16.6	7.3	52.8	25.1	66.9	3.187
Hay-1	94.2	4.1	8.7	79.2	49.3	41.8	1.782
FE-2							
Leucaena seedpod meal-2	90.6	15.3	5.9	59.7	47.7	48.6	2.163
Wheat bran-2	89.2	19.0	6.8	43.9	13.8	75.3	3.658
Diet A2 (control-2)	88.9	18.3	8.7	43.4	13.2	78.2	3.820
Diet C2 (LSM-2)	88.7	17.2	7.2	50.7	29.4	64.6	3.059
Hay-2	91.4	3.6	6.3	78.0	53.0	53.4	2.431

Intake and liveweight performance

Intake of feeds and nutrients and ADG of calves in FE-1 and FE-2 are presented in Table 4a and 4b, respectively. Supplementation of legume seedpod meal diets increased the intake of protein and energy. The daily DM intake of hay expressed per unit metabolic weight (g DM/kg $^{0.75}$) was not different (P>0.05) among treatments but that of treatment B was lower (50.8) than that of treatment C (53.3) (Table 4a).

Table 4a. *Liveweight gain and intake of grass hay, supplement, total CP and estimated digestible energy (DE) in FE-1.*

Variables	Treatment			SE	CV
	A1 (control)	B (ASM)	C1 (LSM)		
Liveweight gain (g/d)	239[a]	250[ab]	486[c]	42	32
Intake					
Grass hay (g DM/d)	1935[a]	2058[a]	2247[a]	135	
(gDM/kg $^{0.75}$ bwt/day)	50.8[a]	50.3[a]	53.3[a]		11
Supplement (g/d)	554	1339	11.5		
Total CP (g/d)	165	271	275		
Estimated DE (Mcal/d)	5.477	7.118	7.525		

abc Treatment means followed by the same letter superscript do not differ significantly (P<0.01).

Table 4b. *Liveweight gain and intake of grass hay, supplement, total CP and estimated digestible energy (DE) in FE-2.*

Variables	Treatment		SE	CV
	A1 (control)	C2 (LSM)		
Liveweight gain (g/d)	276[a]	559[b]	51	34
Intake				
Grass hay (g DM/d)	3214a	3126[a]	104	
(gDM/kg $^{0.75}$bwt/d)	79.8a	77.4a		7
Supplement (g/d)	553	1064		
Total CP (g/d)	212	296		
Estimated DE (Mcal/d)	9.926	10.854		

ab Treatment means followed by the same letter superscript do not differ significantly (P<0.01).

Calves on LSM-1 diet had significantly (P<0.01) higher ADG (486 g/d) than those on ASM diet (250 g/d) and control-1 (239 g/d) (Table 4a). ADG of calves on ASM diet was higher (P>0.05) than control-1. Calves on LSM-2 had (P<0.01) better (P<O.OI) ADG (559 g/d) than control-2 (276 g/d).

Discussion

The amount of ASM diet consumed accounted for 39% of the total diet consumed, while the amount of LSM diet consumed accounted for 33% and 25% of the total diet consumed in FE-1 and FE-2, respectively. The intake of less than the amount of ASM diet offered and the lower intake of grass hay by calves on the ASM diet, could be attributed to the lower digestibility (Table 3) and the higher substitution effect resulting from the higher amount of ASM diet offered. The watering regime of once per day (Weeth et al 1968) and the CP content of less than 7% (Minson and Milford 1967) of grass hay could in part explain the lower DM intake than that recommended by NRC (1976).

The difference between calves on ASM and LSM-1 diets in daily intake of total CP was insignificant and yet differences (P<0.01) were observed in ADG. The superior ADG of calves on LSM diet could in part be attributed to the higher intake of DE and mineral contents of this diet.

Intact seedpods of both *A. brevispica* and *L. leucocephala* have similar *in vitro* DM digestibility and contents of estimated DE, more of which is located in the seeds (Table 2). *A. brevispica* seedpods used lost 35% of their seeds due to dehiscence (Lamprey 1967) and damage caused by a bruchid beetle (Southgate 1983) explaining why the ASM had low content of estimated DE. *L. leucocephala*used in FE-2 contained 80% of their seeds, but the higher CP and IVDMD of wheat bran used in FE-2 elevated the CP and IVDMD of LSM-2 used in FE-2 to a level comparable to that of LSM-1 which contained most of their seeds.

Conclusions

In arid and semi-arid tropical regions where seasonal changes (rainfall etc.) are extreme, both quantity and quality of pasture fluctuate rapidly with consequent periods of critical nutrient deficiencies. On communal African rangelands, which are often chronically overstocked, undernutrition and malnutrition lead to overall reduced growth rates and poor reproductive performance.

It is concluded that seedpods of *L. leucocephala* and *A. brevispica* can be used by smallholder crop–livestock farmers and agropastoralists in arid and semiarid areas to provide feed that is cheap and locally available at least for strategic supplementation to critical classes of cattle, particularly calves in the dry season when other feeds are unavailable. This may lift the major feed constraints to the development of livestock sector in arid and semi-arid areas of developing countries, thus increasing the livestock productivity of smallholder farmers.

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References

Adeneye J.A. 1979. A note on the nutrient and mineral composition of *Leucaena leucocephala* in Western Nigeria. *Anim. Feed Sci. Tech.* 4(3):221–225.

AOAC.(Association of Official Analytical Chemists). 1980. *Official Methods of Analysis.* 13th edition. AOAC, Washington, DC, USA.

Burns R.E. 1963. *Methods of Tannin Analysis for Forage Crop Evaluation.* Univ. of Georgia Agr. Exp. Sta. Tech. Bull. N.S. 32. 14 pp.

Burns R.E. 1971. Method for estimation of tannin in grain sorghum. *Agronomy Journal* 63:511–512.

Damothiran L. and Chandrasekaran N.R. 1982. Nutrition studies with Leucaena forage. *Leucaena Research Reports(LRR)* 3:21–22.

FAO (Food and Agriculture Organization of the United Nations). 1981. *Tropical Feeds: Feed Information Summaries and Nutritive Values.* FAO Animal Production and Health Series 12. FAO, Rome.

Heaney D.P. and Pigden W.J. 1960. Interrelationships and conversion factors between expressions of the digestible energy of forages. *Journal of Animal Science.* 22: 956–960.

ILCA (International Livestock Centre for Africa). 1988. The use of locally available feeds for supplementing calves in southern Ethiopia. *ILCA Annual Report 1987.* ILCA, Addis Ababa, Ethiopia. pp. 6–7.

ILCA (International Livestock Centre for Africa). 1989. Comparative performance of preweaned calves under simulated pastoral management with *Acacia, Vigna* or *Medicago* as supplements. *ILCA Annual Report 1988.* ILCA, Addis Ababa, Ethiopia. pp. 13–14.

Karue C.N. 1974. The nutritive value of herbage in semi-arid lands of East Africa. I. Chemical composition. *E. Afr. For. J.* 40:89–95.

Lamprey H.F. 1967. Notes on the disposal and germination of some tree seeds through the agency of mammals and birds. *E. Afr. Wildl. J.* 5: 179–180.

Manidool C.1983. *Leucaena* leaf meal and forage in Thailand. In: *IDRC, Leucaena Research in the Asian–Pacific Region: Proceedings of a Workshop Held in Singapore, 23–26 Nov. 1982.* IDRC, Ottawa, Canada. pp. 65 –68.

Minson D.J. 1990. The chemical composition and nutritive value of tropical grasses. In: Skerman P.J. and Riveros

F., *Tropical Grasses.* FAO (Food and Agriculture Organization of the United Nations), Rome, Italy. pp. 163–180.

Minson D.J. and Milford R. 1967. The voluntary intake and digestibility of diets containing different proportions of legume and mature Pangola grass *(Digitaria decumbens). Aust. J. Expt. Agric. Anim. Husb.* 7: 546–551.

Naseeven MR., Mapoon L.K., Hulman B., Dolberg F. and Rowe J.B. 1989. Seeds of Acacia *(Leucaena leucocephala)* as a protein supplement to cattle. In: Boodoo A.A., Mapoon L.K., Rajkomar B., Rowe J.B., Dolberg F. and Hulman B. (eds), *Milk and Beef production in Mauritius. Proceedings of a Seminar Held in Reduit, Mauritius, 7–8 June 1988, Reduit, Mauritius.* pp. 1: 15–116.

NRC (National Research Council). 1976. *Nutritional Requirements of Domestic Animals. 4. Nutritional Requirements of Beef Cattle.* Fifth edition. US NAS, Washington, DC, USA. 51 pp.

NRC (National Research Council). 1979. *Tropical Legumes: Resources for the Future. US* NAS, Washington, DC, USA. pp. 123–153.

SAS (Statistical Analysis Systems Institute). 1987. SAS User's Guide: Cary, North Carolina, USA.

Saucedo G., Alvarez F.J., Aniaga A. and Jimenez N. 1980. *Leucaena leucocephala* as a source of protein for calves reared in a restricted suckling system. *Tropical Animal Production* 5:232–235.

Siebert B.D., Hunter R.A. and Jones P.N.1976. The utilization by beef cattle of sugarcane supplemented with animal protein, plant protein or non-protein nitrogen and sulphur. *Aust. J. Exp. Agric. Anim. Husb.* 16: 789–794.

Southgate B.J. 1983. *Handbook on Seed Insects of Acacia Species.* FAO (Food and Agriculture Organization of the United Nations), Rome, Italy.

Steel G.D. and Torrie J.H. 1980. *Principles and Procedures of Statistics — A Biometrical Approach.* McGraw-Hill Book Co., Inc., New York. 633 pp.

Tanner J.C., Reed J.D and Owen E. 1990. The nutritive value of fruits (pods with seeds) from four *Acacia spp.* compared with extracted noug *(Guizotia abyssinica)* meal as supplements to maize stover for Ethiopian highland sheep. *Animal Production* 51:127–133.

Thomas D. and Addy B.L. 1977. Stall fed beef production in Malawi. *World Review of Animal Production(FAO)* 13(1): 23–30.

Tilley J.M.A. and R.A. Terry. 1963. A two–stage technique for the *in vitro* digestion of forage crops. J. *Brit. Grassl.* Soc. 18:104–1l1.

Van Soest P.J. 1963. The use of detergents in the analysis of fibrous feeds. II. A rapid method for determination of fibre and lignin. J. Assoc. Off. *Agric. Chem.* 46:829–835.

Weeth H.J. Lesperance A.L. and Bohman V.R. 1968. Intermittent saline watering of growing beef heifers. *Journal ofAnimal Science* 27: 739–734.

Valeur des gousses *d'Acacia brevispica* et de *Leucaena leucocephala* comme compléments alimentaires de saison sèche pour les veaux en zones arides au Kenya

Résumé

Deux essais d'alimentation ont été effectués afin d'évaluer la valeur nutritive des gousses d'*Acacia brevispica* et de *Leucaena leucocephala* sur la base de leur composition chimique et des performances pondérales des animaux. Dans le premier essai (E_1), 18 veaux pesant en moyenne 132 kg et âges de 5 à 9 mois ont reçu les rations A_1 (ration témoin n° 1); B (complémentation de farine de gousses d'*Acacia*(FGA)) et C_1 (complémentation de farine de gousses de *Leucaena (FGL*$_1$*))*. Dans le second essai (E_2), 16 veaux pesant en moyenne 131 kg et âgés de 5 mois et demi à neuf mois ont requ les rations A_2 (ration témoin n° 2) et C_2 (complémentation de farine de gousses de *Leucaena* (FGL$_2$).

Les rations expérimentales étaient conçues de façon à fournir uniformément 265 g de protéines brutes en vue de couvrir les besoins en protéines brutes nécessaires pour atteindre l'objectifde croissance de 500 g/j. Les veaux des lots témoins ont reçu une ration de base composée de foin et de son de blé dont la valeur protéique était équivalente à celle utilisée pour formuler les rations FGA et FGL. Les animaux ont été pesés une fois par semaine pendant 5 et 4 semaines, respectivement pour les essais E_1 et E_2. Le test F a été utilisé pour comparer les groupes expérimentaux avec les groupes temoins.

Les analyses chimiques des gousses d'*A. brevispica* et de *L. leucocephala o*nt montré que leur teneur en protéines brutes baissait et que leur taux de cellulose (fibres NDF et ADF) augmentait avec la maturité des gousses. Leurs semences avaient des taux de protéines brutes, d'extractif éthére (EE) et de digestibilité *in vitro* de la matière sèche (DIVMS) plus élevés, mais un taux de cellulose plus faible que ceux des gousses vides. Les gousses sèches de *L. leucocephala* avaient une concentration en tanins beaucoup plus élevée que celle d'*A. brevispica.* Ces tanins étaient surtout concentrés daps les gousses vides.

Pour l'essai E_1, les GMQ étaient de 486, 250 et 239 g/j respectivement pour les veaux recevant les rations C_1, B et la ration A_1. Les veaux recevant la ration C_1 avaient un GMQ supérieur ($P<0,01$) à celui des animaux recevant la ration A_1 ou la ration B. Les veaux recevant la ration B avaient un GMQ supérieur ($P>0,05$) à celui des animaux recevant la ration A_1 mais cette différence n'était pas significative. Pour l'essai E_2, les veaux recevant la ration C_2 avaient un GMQ (559 g/j) significativement supérieur ($P<0,01$) à celui des animaux recevant la ration

A_2 (276 g/j), ce qui confnme les résultats du premier essai. Les gousses intactes de ces deux légumineuses arbustives avaient des teneurs en énergie digestible analogues. Toutefois, les gousses d'*A*. *brevispica* utilisés dans le premier essai ne renfermaient que 65% de leurs graines et avaient donc une teneur en énergie plus faible. Enfin, le GMQ des veaux recevant la ration FGA ne reflétait pas la véritable valeur nutritive des gousses intactes.

Il ressort de cette étude que les gousses des deux espèces peuvent, ensemble avec leurs semences, servir à la complémentation stratégique de l'alimentation des ruminants au niveau des petits agriculteurs et agro-pasteurs au cours de la saison sèche, c'est-à-dire en période de pénurie d'aliments du bétail.

The effect of levels of supplementation with *Sesbania sesban* foliage on intake and liveweight changes in goats

G. Y. Kanyama Phiri[1], C. Powell[2] and M. Gill[3]

[1]Bunda College of Agriculture, P.O. Box 219, Lilongwe, Malawi
[2]Natural Resources Institute, Central Avenue, Chatham Maritime, Kent ME4 4TB, United Kingdom
[3]Natural Resources Institute, Central Avenue, Chatham Maritime, Kent ME4 4TB, United Kingdom

Abstract

Optimum levels of inclusion of leaves from *Sesbania sesban* (sesbania) in rations based on maize bran offered as a supplement to maize stover were determined in a 124-day feeding trial with individually fed goats. Twelve supplements were compared; in ten of them bran was substituted by *Sesbania* in 10%–steps up to 100%. Fresh Napier grass and bran were tested as two control treatments. Each supplement was offered to four male uncastrated goats (18 kg initial liveweight) at a level of 500 g DM/day. Daily intake and liveweight gain were measured over 56 and 124-day periods, respectively. Among the supplements, Napier grass showed highest (388 g DM/d) and pure *Sesbania* showed lowest intake (180 g DM/d); on mixtures, the 30:70 *Sesbania*/bran ratio was consumed most. Stover intakes did not differ significantly, and was lowest on pure bran. The highest gain (32 g/day) was obtained on the diet with 10% *Sesbania* and gains were also recorded with 20, 30 and 50% *Sesbania*. On all other rations goats lost weight, ranging from 5 to 15 g/d.

The results suggest that small amounts of *Sesbania* can be included with maize bran as a supplement for growing goats fed on maize stover, but there appeared to be no benefit of including more than 30% *Sesbania.*

Introduction

Although there is adequate information on the use of *Leucaena leucocephala* (leucaena) as a protein supplement for ruminants in Malawi (Thomas and Addy 1977; Banda et al 1985), the threat to its survival from termites and attacks by psyllids (Bray and Sands 1987; Kanyama Phiri et al 1993) calls for alternative sources of tree fodder (Reed et al 1990). *Sesbania sesban* (sesbania) appears a suitable alternative as it is indigenous to sub-Saharan Africa and less prone to damage from termites. Its crude protein and digestibility are comparable to leucaena and *Gliricidia sepium* (Brewbaker 1987; Kanyama Phiri 1993). It grows faster than leucaena, and can provide fodder in the establishment year. With a protein content in excess of 25%, sesbania increases the intake of low-quality feedstuffs (Minson and Milford 1967; Gutteridge and Topark-Ngram 1990); it is mufti-purpose and can be used as a shade-tree and in alley-cropping systems (Mengistu 1988).

The feeding value of sesbania is well documented for cattle (Gutteridge and Shelton 1993), sheep (van Eys et al 1985; Reed et al 1990) and goats (van Eys et al 1986; Ash 1990; Ash et al 1992). As was shown with *Leucaena* and *Gliricidia* (Jones 1979; Chadhokar and Lecamwasan 1982; Karachi 1993), it is expected that feed intake and animal performance peak at a specific level of sesbania supplementation (Ash et al 1992), because polyphenolic compounds in the leaves can negatively affect growth, intake and digestibility when fed in excess (Reed et al 1990). It is against this background that a study was carried out to determine the effect of different supplemental levels of sesbania leaves on feed intake and liveweight change of goats.

Materials and methods

The trial was conducted at Bunda College of Agriculture near Lilongwe, Malawi from 15 October 1992 to 15 February 1993.

Climatic data for this period are given in Table 1. Forty-eight uncastrated local male goats were purchased from a local market. Animals were drenched with Thiabendazole, and sprayed with Chorofenvinphos, at three- and four-weekly intervals to treat internal and external parasites, respectively. The goats were divided into 12 groups of four animals each with an initial average weight of 17.8 ± 2.5 kg. Each group was randomly assigned to one of the 12 supplemental treatments.

Table 1. *Weather data (September 1992–February 1993).*

Month	Total rainfall (mm)	Temperature (°C)		Relative Humidity (%)
		Max.	Min.	
September	–	30	14	57.4
October	–	29	21	49.4
November	1	28	18	61.0
December	131	28	22	88.8
January	166	26	18	92.1
February	376	26	17	113.5

The 12 supplements were: Pure maize bran, pure dwarf *Pennisetum purpureum* (Napier grass), and 10 mixtures of bran and *Sesbania* foliage formulated to provide 10–100% legume. The experiment was laid out as a one-factor, randomised complete block with four animals per treatment. Animals were housed, fed and watered individually. At 0900 h each goat was fed 0.5 kg DM/d of supplement followed by l kg DM/d of maize stover, fed at mid-day. One per cent salt (sodium chloride), dissolved in water was sprinkled on daily stover ration.

The first period covered 56 days with a 14-day adjustment phase prior to a 42-day period to measure intake. Animals were weighed every two weeks prior to the morning feeding. Feed and stover offered and refused were sampled weekly to determine intake. The experiment lasted 124 days; during the final 68 days only weights were recorded.

Crude protein content of the feed was determined by the micro-Kjeldahl procedure (AOAC 1975). Analyses for neutral and acid detergent fibre content followed the procedure described by Goering and Van Soest (1970). The protein precipitation activity (PPA) of tannins extractable in 70% aqueous acetone was determined by the radial diffusion method of Hagerman (1987) as modified by Wood et al (1993). Mineral content of the feeds was determined by atomic absorption.

The significance of the effects of levels of inclusion of sesbania leaves on goat liveweight changes was determined by analysis of covariance, using initial weight as a covariate. Feed and stover intakes were subjected to analysis of variance.

When the F-value was significant, means were separated by Tukey's multiple comparison procedure (Ott 1984), in order to establish significant differences.

Results and discussion

The chemical composition of the supplements is presented in Tables *2* and *3.* As the content of sesbania in the sesbania/bran mix increased from 10 to 100%, there was a corresponding increase in the percentage crude protein of the supplement from 17 to 32%. The percentage of crude protein in the pure (100%) sesbania leaves compares favourably with those of leucaena and gliricidia (Jones 1979*;* Chadhokar and Lecamwasan 1982).

Table 2. *Crude protein, neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents (% DM)* of *supplementary feed.*

	%DM		
Diet	CP	NDF	ADF
Stover	3.3	73.6	51.6
Napier	13.8	60.7	31.6
Bran, 100%	15.6	31.4	6.4
% *Sesbania*			
10[a]	16.9	33.9	6.6
20	17.5	29.8	7.1
30	19.4	26.8	8.1
40	20.6	26.3	8.4
50	22.5	28.2	8.5
60	23.8	25.5	9.8
70	27.5	26.8	10.2
80	28.1	21.0	9.5
90	29.4	24.9	10.3
100	31.9	22.9	12.3

a. Supplement of 90% bran and 10% *Sesbania:* (etc).

Table 3. *Mineral content of the goat diets.*

	% DM			PPM		
Diet	Ca	Fe	P	Cu	Zn	Na
Dwarf Napier	2.90	0.59	0.60	5.00	65.0	140
Maize bran	4.00	0.66	0.15	5.00	15.0	270

% *Sesbania*						
10%	3.45	0.43	0.45	2.00	65.0	120
20%	3.05	0.95	0.28	5.00	55.0	220
30%	3.85	0.65	0.34	6.00	55.0	300
40%	3.65	0.43	0.10	5.00	50.0	230
50%	3.05	0.44	0.38	6.00	50.0	340
60%	3.30	0.68	0.30	5.00	50.0	220
70%	3.55	0.65	0.41	5.00	45.0	240
80%	2.80	0.74	0.12	3.00	40.0	200
90%	3.45	0.78	0.47	3.50	50.0	370
100%	2.95	1.01	0.25	6.00	35.0	280

Liveweight gain did not respond to increasing protein content of the diet (Table 4) being highest on 10% sesbania after 56 days, with the goats losing weight on supplements containing more than 30%sesbania.

Table 4. *Mean intake daily and weight change of goats over 56 days.*

	Intake (kg DM/d)			Weight change (g/d)	
Type of supplement	Supplement	Stover	Total	56 days	124 days
100% Bran	0.18c	0.20b	0.38	–32	–16
100% Napier	0.39a	0.29a	0.68	–35	–23
% *Sesbania*					
10%	0.26abc	0.26ab	0.52	+32	+15
20%	0.31ab	0.28ab	0.59	+28	+16
30%	0.35ab	0.39a	0.74	+19	+30
40%	0.24bc	0.25ab	0.49	–38	–7
50%	0.31ab	0.28ab	0.59	+10	+0
60%	0.26abc	0.26ab	0.52	–38	–16
70%	0.33ab	0.28ab	0.61	–27	–6
80%	0.28ab	0.26ab	0.54	–27	–6
90%	0.29abc	0.27ab	0.56	–40	–16
100%	0.24bc	0.25ab	0.49	–59	–5

Means followed by different letters in a column are significantly different at thee 5% level.

On supplements containing 10–30% sesbania and 70–90% bran goats gained 20–30 g/d over 56 days, which declined to 13–16 g/d when measured over a 124–d period. On the 30:70 sesbania–bran supplement the highest stover intake was reached (Table 4) and the entire diet provided 80 g CP/d and 230 g ADF/d converting to a content of 11% and 31%, respectively.

The loss of weight may be related to protein binding effects of tannins in the sesbania, which had a moderatively high protein precipitation activity (sesbania showed a PPA = 3 84 cm ^{2}/g

DM) compared to PPAs of low tannin leaves of leucaena of 100 to 150 cm^2/g (C.D. Wood, personal communication). Tannins – naturally occurring anti-nutritional polyphenolic compounds in leaves of most tree fodders, including sesbania–have been widely reported to form complexes with dietary proteins, thereby decreasing the digestibility of the protein by the microbes in the gastro-intestinal tract (Waterman et al 1980; Mueller- Harvey et al 1987). Research elsewhere (Reed et al 1990) has demonstrated high levels of condensed tannins in *Acacia cyanophylla protein*. However, the observation that two goats died on the 100% sesbania diet suggests that toxins were present in the sesbania.

An alternative explanation for decreasing liveweight gains when the proportion of sesbania in the supplement increased above 30%, may be that energy intake became limiting, since energy content of sesbania leaves is low as shown by a low NDF% of pure leaf. Similar observations have been made for other legume species (Thomas and Addy 1977).

It was observed that goats maintained on pure bran and pure Napier grass supplement also lost weight. The high fibre content (40% ADF) of the Napier grass and stover resulted in low digestibility and contributed to the heavy loss of weight (Table 4). The loss in weight (16 g/d) by goats maintained on the pure bran which had a similar protein and fibre content as the diet with 10% sesbania (Table 2) may be due to scouring associated and low intake (Table 4). Chronic scouring was observed in all goats on pure bran, suggesting that it should not be fed at a level of 500 g/d together with high fibre diet of maize stover.

Intake of supplement did not differ significantly with level of sesbania fed, but the goats ate more Napier grass and less bran ($P<0.05$); the latter also significantly lowered the intake of stover relative to the other treatments while the level of sesbania had no effect.

A similar trend was also observed when the experimental period was extended to 124 days (Table 4). The trend in liveweight gain results appear to suggest that the content of sesbania in the diet should not exceed 30% (Ash et al 1992).

Conclusions

This experiment has demonstrated that small amounts of sesbania leaf can be included in a maize bran supplement to provide protein for growth and for meat production. It has been further demonstrated that high levels of sesbania will depress intake and weight gain of goats.

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Means followed by different letters in a column are significantly different at the 5% level.

References

Ash A.J.1990. The effect of supplementation with leaves from the leguminous trees *Sesbania grandiflora, Albizia chenensis* and *Gliricidia sepium* on the intake and digestibility of guinea grass hay by goats. *Anim. Feed* Sc. *Technol* 28: 225–232.

Ash A.J., Petaia L. and Ako H. 1992. Nutritional value of *Sesbania grandiflora* leaves for monogastrics and ruminants. *Tropical Agriculture (Trinidad)* 69: 223–228.

AOAC (Association of Official Analytical Chemists). 1975. *Official Methods of Analysis.* 12th edition. Washington, DC, USA.

Banda J.L.L. and Ayoade J.A. 1986. Leucaena leaf hay *(Leucaena leucocephala* cv Peru) as protein supplement for Malawian goats fed chopped maize stover. In: Preston P.R. and Nuwanyakpa M.Y. (eds), *Agricultural Byproducts to Livestock in Africa. Towards Optimal Feeding of Agricultural Byproducts to Livestock in Africa, Proceedings of a Workshop held in University of Alexandria, Egypt, Oct. 1985.* ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. 180 pp.

Bray R.A. and Sands D.P.A 1987. Arrival of the *Leucaena psyllid* in Australia. Impact, dispersal and natural enemies. *Leucaena Research Reports* 7: 61–66.

Brewbaker J.L. 1987. Leucaena: a multipurpose tree genus for agroforestry. In: Stepler H.A. and Nair P.K.R. (eds), *Agroforestry, a decade of development.* ICRAF (International Centre for Research on Agroforestry), Nairobi, Kenya. pp. 89–116.

Chadhokar P.A. and Lecamwasana. 1982. Effect of feeding *Gliricidia muculata* on growth of ewes. *Trop. Grassl.* 14:78–82.

Goering H.K. and Van Soest P.J. 1970. *Forage and Fibre Analysis. (Apparatus, Reagents, Procedures and Some Applications).* Agriculture Handbook 379, Agricultural Research service, Department of Agriculture, Washington, DC, USA. 20 pp.

Gutteridge R. and Shelton H.M. 1993. *Sesbania sesban* in Australia. ILCA *Newsletter.* 12: (1).

Gutteridge R. and A. Topark-Ngarm. 1990. Fodder. In: Evans D. and Macklin B. (eds.), *Perennial Sesbania, Production and Use.* N.I.F.T.A. pp. 17– 21.

Hagerman A.E.1987. Radial diffusion method for determining tannins in plant extracts. J. *Chemical Ecology* 13: 437–449.

Jones R.J. 1979. The value of *Leucaena leucocephala* as food for ruminants in the tropics. *World Animal Review* 31: 13–33.

Kanyama Phiri G.Y., Dzowela B.H. and Kategile J.A. 1993. Response of *Sesbania* to N and P combinations and adaptability in a subhumid environment. In: Kategile J.A. and Adoutan S.B. (eds),*Collaborative Research on* Sesbania *in East and Southern Africa.* African Feed Resources Network (AFRNET), Nairobi, Kenya. pp. 70–90.

Karachi M. 1993. Animal Production for Agroforestry. Paper presented at the in-zone agroforestry course in Lusaka, Zambia, 22nd March to 2nd April 1993.

Mengistu S. 1988. Report of a survey and collection mission for *Sesbania* germplasm in Tanzania. Forage Agronomy Section. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 21.

McCurrough I. 1991. High performance liquid chromatography of flavonoids in barley and hops. *J. Chromatograph* 218:683–693.

Minson D.J. and Milford R. 1967. The voluntary intake and digestibility of diets containing different proportions of legume and mature pangola grass *(Digitaria decumbens). Australian Journal of Experimental Agriculture and Animal Husbandry* 7:546–551.

Mueller-Harvey I., Reed J.D. and Hartely R.D. 1987. Characteristics of phenolic compounds, including flavoids and tannins, of ten Ethiopian browse species by high performance liquid chromatography. J. Sci. *Food Agri.* 39:1–14.

Ott L. 1984. An introduction to statistical methods and data analysis. In: Walden H. (ed). PWS Publishers, Duxbury Press, Boston, Mass., USA. 775 pp.

Reed J.D., Soller H. and Woodward A. 1990. Fodder tree and straw diets for sheep: Intake, growth, digestibility and the effects of Phenolics on nitrogen utilization. *Animal Feed Science and Technology* 30:39–50.

Reed J.D., Horvah P.J., Allen M.S. and Van Soest P.J. 1985. Gravimetric determination of soluble phenolics including tannins from leaves by precipitation with trivalent ytterbium. *Journal of the Science of Food and Agriculture* 36:255–261.

Thomas D. and Addy B.L. 1977. Tropical pasture legumes and animal production in Malawi. *World Review of Animal Production (FAO)* 13:(3)47–52.

Van Eys J.E., Mathius LW., Rangkuti M. and Johnson W.L. 1985. *Gliricidia, Leucaena* and *Sesbania* supplementation of chopped napier grass for growing lambs. *Tropical Animal Production.*

Van Eys J.E., Mathius I. W., Pongsapan P. and Johnson W.L. 1986. Foliage tree legumes *Gliricidia, Leucaena* and *Sesbania* as supplement to napier grass diets for growing goats. J. *Agric. Sci.*Cambr. 107:227– 233.

Waterman P.G., Mbi C.N., McKey D.B. and Gartlan J.S.1980. African rainforest vegetation and rumen microbes: phenolic compounds and nutrients as correlates of digestibility. *Oecologia* 747:22–33.

Wood C.D., Tiwari B.N., Plumb V.E., Powell C.J., Roberts B.T. and Gill M.1993. Interspecies differences in tannin activity of leaves from species of Nepalese browse trees. In: Gill M., Owen E., Pollot G.E. and Lawrence T.L.J. (eds), *Animal Production in Developing Countries.* Occasional Publication 16. *British Society of Animal Production. pp.* 212– 213.

Effet de différents niveaux de complémentation avec des feuilles de *Sesbania sesban* sur l'ingestion et l'évolution du poids chez les caprins

Résumé

Un essai d'alimentation de 124 fours a été effectué pour déterminer les niveaux optimum d'incorporation de feuilles de *Sesbania sesban* à des rations à base de son de maïs à offertes comme complément de tiges de maîs à des caprins nourris individuellement. 12 compléments ont été comparés dont 10 pour lesquels le son de maïs a été progressivement remplacé par *Sesbania* de 10 en 10% jusqu'à 100%. Deux compléments, à savoir l'herbe à éléphant fraîchement coupée et le son de maïs ont été utilisés. Chaque complément a été donné à 4 boucs entiers (18 kg de poids initial) à raison de 500 g de MS/j. L'ingestion journalière et le gain de poids vif ont été mesurés respectivement pendant 56 et 124 fours. Le niveau de consummation des compléments était maximum pour l'herbe à éléphant (388 g de MS/j) et minimum pour *Sesbania* (180 g de MS/j); quant aux mélanges, c'est la ration contenant 30% de *Sesbania* et 70% de son de maîs qui a été la plus consommée. L'ingestion de tiges de maîs n'etait pas significativement différente et était minimum avec le son de maïs pur. Le gain moyen quotidien (GMQ) était maximum avec la ration à 10% de *Sesbania* (32 g/j); des gains moms importants avaient été enregistrés avec les rations contenant 20, 30 et 50% de *Sesbania.* Toutes les autres rations avaient occasionné des pertes de poids allant de 5 à 15 g/j.

Ces résultats montrent que l'alimentation de caprins en croissance recevant du son de maïs peut être complémentée avec de faibles quantites de *Sesbania* mats qu'il n'y a aucun avantage à dépasser le taux de 30%.

Effect of supplemental peanut hay on performance of lactating Tswana does and kids post-weaning

J. Macala[1], V. Molefe[2], B. Sebolai[2] and K. Laletsang[1]

[1]Department of Agricultural Research, Animal Production Research Unit
Private Bag 0033, Gaborone, Botswana

[2]Botswana College of Agriculture, University of Botswana
Private Bag 0027, Gaborone, Botswana

Abstract

Feeding of small ruminants during the dry season is mainly based on natural rangelands. However, deficiencies of natural pastures in nitrogen, energy and mineral content reduce their utilization by ruminants. As a result, productivity of animals dependent on natural pastures is adversely affected. Therefore, a study was carried out to evaluate the effect of peanut hay given to lactating Tswana does and the effect of the urea–molasses blocks with or without peanut hay on the post-weaning performance of kids grazing natural pastures in the dry season.

Three groups of 10 lactating does aged 24 months with an initial liveweight of 37 kg were used in a feeding trial. The first group was not supplemented whilst the second and third groups were given 300 and 600 g of peanut hay per animal daily, respectively. Supplemented does had higher final weight, average daily gain and milk production than the unsupplemented goats ($P<0.001$).

Post-weaning performance of kids fed urea–molasses blocks and peanut hay was superior to the kids fed urea–molasses blocks alone. Compensatory growth was observed in the kids from the control group of does.

The economic results (in Pula (P)) showed gross margins of-P534, -P35 and P346 for does offered 0, 300 and 600 g/day peanut hay. It was concluded that using peanut hay for supplementary feeding lactating does would be profitable for farmers owning at least nine lactating does.

Introduction

In Botswana, the population of sheep and goats is estimated at 0.32 and 2.09 million, respectively (Ministry of Agriculture 1990), most of which are kept by small-scale farmers. Small ruminants play a significant role in the welfare of rural families as they provide both meat and milk as sources of energy and protein for human consumption. Goat meat is popular in Botswana, and demand is particularly high during religious and cultural festivals. Smallstock are also valued for their manure, which serves as a source of fuel and fertiliser; goat manure is said to be higher in quality than that from cattle manure (Ntseane 1991). Smallstock require relatively little capital to acquire and to feed compared to cattle and therefore, they are popular among various income groups, including poor farmers. In fact, as smaller farm sizes become more widespread, the importance of goats will increase.

Feeding small stock by small-scale farmers is based on natural rangelands and during the dry season, browse becomes the major feed resource for goats (APRU 1983–84; 1989). Studies comparing the performance of kids showed high mortality rates for kids born in spring (APRU 1990), probably due to the scarcity of good-quality fodder for both lactating does and their kids. However, in order to realise the advantages of keeping goats, better management packages, including better feeding, particularly in the dry season, and disease control must be developed to reduce the high pre- and post-weaning mortality of kids and thus increase overall productivity.

Legume crop stovers (cowpeas, jugo beans and peanuts) available after grain harvesting can be utilised for livestock feeding. Immediately after harvesting and threshing of nuts, most farmers either burn the residues or leave them in the field. However, since peanut hay has a high crude protein content (10.5%), it can serve as a supplement to low quality roughage. Peanut hay has relatively high apparent digestion coefficients (dry matter 0.60, organic matter 0.64, crude protein 0.63 and gross energy 0.65 (Hadjipanayiotou 1988)). Mohamed-Saleem and von Kaufmann (1989) reported values of 10.5, 5.04 and 0.07% for crude protein, calcium and phosphorus content in peanut haulms after harvest and threshing. Ayoade and Njewa (1983) reported higher feed intake and digestibility of nutrients when the peanut hay was chopped compared to when ground. Ground peanut hay was not well utilised by the rumen micro-organisms since its particle size was reduced and therefore its rate of passage from the rumen was increased (Ayoade and Njewa 1983). Ikhatua and Adu (1984) reported high daily liveweight gain and feed efficiency of Red Sokoto goats fed peanut haulms compared to those given *Digitaria* hay. The conclusion drawn from these studies was that peanut haulms are a good-quality roughage with adequate protein.

The availability of peanut hay among arable farmers who keep smallstock justifies the need to investigate this feed source as a supplement for goats grazing natural pastures during the dry season. Therefore, this study investigated 1) the effect of supplemental peanut hay on lactating Tswana does grazing natural rangelands during the dry season, and 2) the effect of urea–molasses blocks with or without peanut hay on post-weaning performance of the Tswana kids.

Materials and methods

Site

The study was conducted at Sunnyside Ranch, 10 km north of Lobatse. The goats grazed a 37-ha paddock which contained several species of browse. The vegetation of Sunnyside ranch is classified as a mixed *Acacia* woodland associated with *Tarconanthus camphoratus, Grewia flava* and *Euclea schimperi* characterised by hardveld soils with scattered rock outcrops.

The paddock grazed by the experimental animals was assessed for both woody plant composition and density was determined by using a 50 ×100 m belt transect; within this transect plant species were counted and grouped into heights of 0–0.50, 0.6–1.0, 1.1–2.0, 2.1–3.0 and >3.0 metres. Samples of the trees and shrubs with a height of <3 m i.e. within the browsing range of goats, were hand-clipped and taken for chemical analysis.

Animals

Three groups of *10* lactating Tswana does aged 24 months with an initial average liveweight of 37.2 kg were used. The first group received no supplement (control) whilst the second and third groups were confined in separate kraals and fed 300 or 600 g of peanut hay per doe daily. The three groups had access to water and a mineral premix consisting of dicalcium phosphate and salt in a ratio of 1:2. All animals were kraaled overnight (from 1600 to 0800 h). The supplementary feeding trial lasted 93 days, after which the kids were weaned and used in a post-weaning study.

Post-weaning trial

After completing the experiment with lactating does, the kids were randomly allocated to two treatments. The first group was fed urea–molasses blocks with peanut hay and the second group urea–molasses block alone. Kids had access to natural grazing and were kraaled overnight (1600–0800 h). The supplement was fed in the morning at 0730 h for 124 days.

Management of animals

The does and kids were weighed at the start of the trial and monthly thereafter. All animals were dewormed using Valbarzen for round worm parasites. The lactating does were milked once per day at 0800 h; only one teat was milked and the other left for suckling. After milking, goats and kids were allowed out of the kraal to graze natural pastures until 1600 h, after which does were kraaled separate from their kids.

Chemical analysis of feeds

Samples of peanut hay and clipped browse plants were taken for analysis of dry matter, crude fibre, crude protein, calcium and phosphorus according to methods of AOAC (1984). Analysis for *in vitro*organic matter digestibility was done according to the procedure of Tilley and Terry (1963).

Statistical analysis

Data on initial weight, final weight, liveweight change, daily gain and milk production were subjected to a one-way analysis of variance with three and two treatment levels for lactating does and post weaning kids, respectively.

Initial weight was used as a covariate for final weight, liveweight change and average daily gain in the post weaning trial. If significant F-ratios were obtained, differences among treatment means were tested using orthogonal contrasts (Snedecor and Cochran 1967).

Results

Feed composition

The paddock grazed by the goats showed a diverse plant cover which was dominated by *Acacia* and *Grewia* species. *Grewia* species are easily browsed by goats because they do not have thorns whilst the accessibility of *Acacia* species is somehow limited by their thorns and of their canopy density. It was observed that 94% of the trees and shrubs were within the height of 2 m (Table 1). Other species providing browse but with lower density were *Ziziphus mucronata, Combretum hereroense, Dichrostachys cinerea, Tarconanthus camphoratus,* *Erhetia rigidia* and *Boscia albitrunca.* A summary for the chemical analysis of the clipped shrubs and trees is presented in Table 2. The crude protein content for the sampled shrubs and trees ranged from 6.0 to 15.1% and the *in vitro* dry matter digestibility from 17.6 to 58.9%.

Table 1. *Number of shrubs and trees by species and in height classes within a 50 × 100 m belt transect (0.5 ha).*

	Height category (m)					
Species	0–0.5	0.6–1.0	1.1–2.0	2.1–3.0	>3.0	Total
Acacia tortilis	228	250	220	75	20	793
A. caffra	10	10	5	0	0	25
A. nilotica	5	35	5	5	5	55
A. mellifera	5	0	5	0	0	10
A. burkiana	0	5	0	0	0	5
A. robusta	0	0	0	5	0	5
A. karoo	45	0	5	0	0	50
Grewia flava	116	210	380	0	0	706
G. flavescens	0	5	25	0	0	30
G. bicolor	35	25	45	0	0	105
Combretum hereroense	80	45	20	0	0	145
Euclea schimperi	215	55	180	20	0	470
Dichrostachys cinerea	90	45	45	0	0	180
Boscia albitrunca	45	5	5	5	0	60
Ziziphus mucronata	5	10	15	20	10	60
Maytenus senegalensis	35	15	40	0	0	90
Peltophorum africanum	5	0	0	0	5	5
Diospyros lysioides	0	0	0	0	5	5
Xamania americana	5	20	25	0	0	50
Erhetia rigidia	20	25	15	0	0	60
Tarconanthus camphoratus	5	20	5	10	0	40
Total	949	780	1040	140	40	2949
(%)	32	27	35	5	1	100

Table 2. *Chemical analysis of the dominant trees and shrubs in the paddock grazed by goats.*

	Analysis of dry matter (%)			
Species	CP	Ca	P	IVDMD
Acacia karro	11.2	1.37	0.11	38.7
A. robusta	14.2	0.76	0.18	31.6
A. caffra	11.9	0.84	0.12	33.7
A. tortilis	15.1	1.10	0.14	39.2

A. nilotica	11.4	0.19	0.21	46.9
Euclea schimperi	6.0	0.86	0.03	17.6
Tarchonanthus camphoratus	9.8	0.79	0.12	46.0
Grewia flava	8.8	1.23	0.13	37.1
G. bicolor	12.4	1.33	0.12	27.7
Peltophorum africanum	9.8	1.84	0.11	29.4
Maytenus senegalensis	8.5	2.55	0.10	58.9
Xamania americana	11.2	1.23	0.17	27.9

CP = crude protein; Ca = calcium; P = phosphorus; IVDMD = *in vitro* dry matter digestibility.

Degradation characteristics for peanut hay showed that dry matter solubility and the potential degradable fractions were 37 and 40%, respectively, whilst the degradation rate constant was 0.089. Peanut hay contained 10% crude protein, 6.1% calcium content and had an *in vitro* organic matter digestibility of 71.8% (Table 3).

Table 3. *Chemical analysis of peanut hay fed as a supplement to the lactating does and kids (post-weaning).*[1]

No. of samples	Analysis of dry matter (%)					
	DM	CP	CF	Ca	P	IVOMD
13	94.2	10.2	39.9	601	0.1	71.8

1 Mineral premix consisting of dicalcium phosphate and salt (1:2) was provided *ad lib*. dicalcium phosphate contained 14.91% Ca and 10.01% P.

CP = crude protein; CF = crude fibre; Ca = calcium; P = phosphorus.

IVOMD =*In vitro* organic matter digestibility (%).

Performance of lactating does and kids

Feeding lactating does with peanut hay resulted in higher ($p<0.001$) final weight and daily gain compared to unsupplemented does (Table 4). Liveweight change and daily gain were higher ($P<0.001$) for lactating does given 600 g than for does given 300 g peanut hay.

Table 4. *Least squares means for lactating Tswana does fed three levels of supplemental peanut hay.*[1]

Item	Level of supplement (g)		
	0	300	600
Initial wt, kg	37.0±1.97	37.7±1.97	36.9±1.97
Final wt, kg	30.3±2.40	37.4±2.40	40.7±2.40
Change, kg	–6.7±1.02	–0.31±1.02	3.8±1.02

Daily gain, g	–72.8±0.01	–3.3±0.1	41.3±0.01
Milk production, kg/d	1.15±0.11	1.71±0.10	2.16±0.10
Number of does	10	10	10
Planned contrasts:	Level of significance	Planned contrasts:	Level of significance
Final liveweight:		Daily gain:	
Control vs supplement	0.001	Control vs supplement	0.0002
Supplement 300 vs 600	0.347	Supplement 300 vs 600	0.0009
Liveweight change:		Milk production:	
Control vs supplement	0.001	Control vs supplement	0.001
Supplement 300 vs 600	0.010	Supplement 300 vs 600	0.003

1 Number of days of experiment = 93.

Furthermore, the milk production for the supplemented does was higher (P<0.001) compared to does in the control group. Increasing the level of peanut hay to 600 g resulted in an increase (P<0.003) in the amount of milk produced by the goats. The average response was 0.17 kg of milk per 0.1 of peanut hay fed.

Kids from does that were fed peanut hay had higher (P<0.001) final weight, liveweight change and daily gain than kids from the unsupplemented does. In addition, kids suckling does given 600 g peanut hay had higher (P<0.001) final weight, liveweight change and daily gain than kids from does offered 300 g peanut hay (Table 5). The average feed efficiency of kids was 7.7 kg of hay for 1 kg of gain.

Table 5. *Least squares means for kids suckling does supplemented with three levels of peanut hay.*[1]

	Supplementation of does (g)		
Item	0	300	600
Initial LW, kg	7.0±0.93	6.0±0.77	6.0±0.87
Final LW, kg .	11.6±0.76	14.6±0.64	17.5±0.71
Change, kg	4.6±0.55	8.6±0.46	11.5±0.51
Daily gain, g/g	50±11	93.51±0.01	125.0±0.01
Number of kids	7	10	8
Planned contrasts:	Level of significance	Planned contrasts	Level of significance
Final liveweight		Daily gain	
Control vs supplement	0.001	Control vs supplement	0.0001
Supplement 300 vs 600	0.020	Supplement 300 vs 600	0.0001
Liveweight change			
Control vs supplement	0.001		
Supplement 300 vs 600	0.001		

1 Number of days of experiment = 93.

Post-weaning kids

The final weight and liveweight change of kids offered the urea–molasses block plus peanut hay was 37% higher (P>0.05) than for kids offered the urea–molasses block alone (Table 6).

Table *6.* *Effect of the urea–molasses block with or without peanut hay on the performance of kids post-weaning.*

	Supplements	
Item	1	2
Initial wt, kg	13.7±0.8	113.7±0.8
Final wt, kg	22.1±0.7	19.8±0.7
Change, kg	8.4±0.7	6.2±0.7
Daily gain, g	67±4.4[a]	49±4.2
Number of kids	12	13

1= Peanut hay fed with urea–molasses (50 g peanut hay + 40 g block per kid daily).

2 = Urea–molasses block alone (40 g block/animal/day).

a Number of days of post-weaning experiment =124.

Means within the same row followed by different superscript are significantly (P<0.05) different.

Performance of kids from the different doe treatments within each of the post weaning treatments were also compared. There was no difference in the final liveweight, liveweight change and daily gain among kids from the different doe treatments fed the urea–molasses block plus hay (Table 7). Kids from the does given 300 g/day peanut hay pre-weaning had lower daily gain than kids from does offered 600 g/day peanut hay.

Table 7. *Effect of peanut hay plus the urea–molasses block on performance daily gains of kids from does fed different levels of supplemental peanut hay.*

	Hay supplementation of does		
Item	0	300	600
Initial wt, kg	11.2±1.4	13.8±1.3	16.0±1.6
Final wt, kg	19.8±1.0	20.4±0.8	24.9±1.1
Change, kg	8.6±1.1	6.6±0.9	8.9±1.2
Daily gain, g	70±9	53±7	72±10
Number of kids	4	5	3
Planned contrasts:	Level of significance	Planned contrasts	Level of significance
Final liveweight		Daily gain	
Control vs supplement	0.843	Control vs supplement	0.714
Supplement 300 vs 600	0.098	Supplement 300 vs 600	0.060

Weight change			
Control vs supplement	0.714		
Supplement 300 vs 600	0.060		

1 Number of days of experiment = 124.

Information on the performance of kids from the different doe treatments offered the urea–molasses block alone is presented in Table 8. There were no differences (P>0.348) in the final liveweight of kids from the control and/or the supplemented does.

Table 8. *Effect of the urea–molasses block on daily gains of kids from does fed different levels of supplemental hay*[1]*.*

Item	Hay supplementation of does (g)		
	0	300	600
Initial wt, kg	11.0±1.6	14.2±1.3	15.8±1.3
Final wt, kg	2.08±1.1	20.6±0.8	18.4±0.9
Change, kg	8.8±1.3	6.8±0.9	4.5±1.0
Daily gain, g	70±10	54±7	36.1±8
Number of kids	3	5	6
Planned contrasts:	Level of significance	Planned contrast:	Level of significance
Final weight		Daily gain	
Control vs supplement	0.348	Control vs supplement	0.046
Supplement 300 vs 600	0.352	Supplement 300 vs 600	0.092
Weight change			
Control vs supplement	0.047		
Supplement 300 vs 600	0.094		

1 Number of days of experiment = 124.

However, the kids from the control group does gained more (P<0.05) weight than kids of the supplemented does, showing evidence of compensatory growth for the kids from the unsupplemented does.

Economic analysis

An economic analysis was performed on the studies discussed above. A gross-margin (GM) analysis included feed costs (assuming that the farmer is harvesting his own peanut stover), the cost of molasses (as shown in Table 9), labour costs (assuming the minimum government wage rate for daily paid labourers), expenditure on drugs and veterinary care, milk sales (valued at market price) and the value of meat gained (live weight changes). Table 10 shows the results of this analysis.

Table 9. *Ingredients, composition (kg) and crude protein* (%) *of the urea–molasses block.*

Components	Composition (kg)	Costs (Pula)	CP
Molasses	5.00	2.31	1.50
Wheat bran	2.00	0.44	1.60
Urea	1.00	0.72	28.70
Salt	0.50	0.08	_
Dicalcium phosphate	0.50	0.40	_
Clay/cement	1.00	0.19	_
Total	10.00	4.14	31 80

CP = Crude protein.

T**able 10.** *Gross-margin analysis of a supplementary feeding package for lactating Tswana goats.*

		1 goat			10 goats	
	Control	300	600	Control	300	600
Costs (variable)						
Feed	0.0	3.7	7.4	0.0	36.5	74.0
Labour	1346	1346	1346	1346	1346	1346
Drugs	0.2	0.2	2.0	0.2	2.0	2.0
Total	1346	1349.81	1353	1348	1383	1422
Returns						
Milk	90.	135.2	171.1	908.6	1351.8	1711.0
Meat (weight change)	–9.7	–0.4	5.5	–97.2	–4.4	55.1
Total	81.1	134.6	176.6	811.4	1347.4	1766.1
Gross margins[1]	–1265.0	–1215.2	–1177	–5366	–36.1	44.1

1 Gross margin = total revenue – variable costs.

While the technical results showed no statistical difference between the does fed 300g or 600 g/day peanut hay in terms of weight gain (Table 9), the overall economic results including milk production showed that the does fed 600 g peanut hay daily performed better. The gross-margin analysis showed that for the 10 goats in each of the three groups there were losses of -P537, -P37 for the control and the 300 g groups and P344 and a profit of 600 g group. Even though there is a loss from feeding 300 g peanut hay, this is better than the P536 loss that would result from not supplementing lactating does at all.

Since labour is paid on daily basis, it is a fixed cost in the short run in that it is the same irrespective of the number of goats. This can change in the long run with a notable change in the number of goats.

A labourer would be paid the same daily wage whether he is feeding and milking 1, 5 or 10 goats. Thus labour costs per unit of output would decrease as the number of goats increases. As a result, higher profit can be realised by keeping a larger number of does. In this analysis, GMs were found to be negative, but rose as the number of goats increased becoming positive with nine goats. Therefore, it can be inferred that this intervention would not benefit farmers who managed less than nine lactating does.

This analysis is based on feed that is harvested on farm and the cost of urea molasses–urea blocks (Table 9). Thus the cost of hay refers only to harvesting cost. If feed was to be purchased a different picture would emerge. In addition to the cost of purchasing feed, there would be transportation costs, which can be substantial depending on the distance of a particular farm from the source of feed.

Discussion

The information on plant density and composition showed that the woody stratum is dominated (94%) by the low shrubs (0.5 to 2 m) which are within the browsing height of goats (Table 1). It was observed that *Acacia* species were dominant but that browsing by goats was hampered by their high thorniness. Also, due to the high canopy density access to tree foliage and pods of *Acacia* species was difficult in particular for kids. The other species with good browse occurred at low density thus suggesting that the unsupplemented does experienced feed shortages as indicated by their loss in liveweight and lower milk production. However, the dominating shrubs/trees had high crude protein and calcium contents indicating that where the plant density and access is not limiting they may provide good fodder for goats. In contrast, *in vitro* dry matter digestibility (IVDMD) was on average low which may be due to low solubility of the available nitrogen and high tannin content of the browse.

Given values of 10.2, 6.1 and 0.13% for crude protein, calcium and phosphorus, respectively, the peanut hay fed to the goats was comparable to contents reported by Mohamed-Saleem and von Kaufmann (1989). Feeding additional protein enabled the lactating does to maintain their liveweight and to increase their milk production. Likewise, Ikhatua and Adu (1984) found that Red Sokoto goats maintained liveweight when supplemented with peanut haulms during the dry season. While in normal rainfall years, goats may meet their energy and protein requirement from grass and browse during drought years, there is a need to provide supplementary nitrogen for rumen microbial requirements and by-pass protein in particular for lactating does.

Kids suckling does supplemented with 600 g/day peanut hay had higher growth rates than kids from the 300 g or unsupplemented groups because of the higher milk yield from does fed the high level. The high daily gain of kids given urea–molasses and peanut hay showed the complementary effect of the two feeds. Furthermore, it was evident that kids of the control does gained more weight when offered peanut hay and the urea–molasses block than kids of the supplemented does indicating some compensatory growth in the control group.

Conclusions

The diversity of browse plants present and browsed in Sunnyside ranch were not sufficient to maintain liveweight of lactating does despite their high nutrient content. Parameters measured such as liveweight change, daily gain and milk production were improved with peanut hay supplementation. Furthermore, kids from the supplemented does performed better than those reared by unsupplemented does. Post-weaning performance of kids fed the urea–molasses block and peanut hay was superior to the kids fed the urea–molasses block alone. Compensatory growth was observed in the kids of the control group of does. The economic results showed gross margins of P-537, -7 and P344 for 10 does offered 0, 300 and/or 600g/day peanut hay. It is concluded was that the intervention of using peanut hay would benefit a farmer who has at least nine lactating goats. According to Ministry of Agriculture. (1990) about 60% of smallstock farmers have herd sizes ranging between 10–25 goats.

References

Agricultural Information and Public Relations Division. 1992. Feeding of livestock during the dry season and drought conditions. *Agrinews* 23:8–9.

AOAC (Association of Official Analytical Chemists). 1984. *Official Methods of Analysis.* 14th edition. Washington, DC, USA.

APRU (Animal Production and Range Research Unit). 1984. *Livestock and Range Research in Botswana.* Ministry of Agriculture, Gaborone, Botswana. pp. 364.

APRU (Animal Production and Range Research Unit). 1989. *Livestock and Range Research in Botswana.* Ministry of Agriculture, Gaborone, Botswana. pp. 44–52.

APRU (Animal Production and Range Research Unit). 1990. *Livestock and Range Research in Botswana.* Ministry of Agriculture, Gaborone, Botswana. pp. 8–52.

Ayoade J.A. and Njewa B.J. 1983. Utilization of Agricultural residues by livestock 1. Physical forms as a factor affecting the utilization of bean and groundnut haulms by goats. *Research Bulletin*12:61–68. Bunda College of Agriculture, University of Malawi.

Hadjipanayiotou M. 1988. The Feeding Value of Peanut hay and Silage made from Peanut shells and Citrus pulp with addition of Urea. In: *Reports* of *Agricultural Research Institute (Cyprus)* #33. 8 pp.

Ikhatua I.F. and Adu I.F. 1984. A comparative evaluation of the utilization of groundnut hay and *Digitaria smutsii* hay by Red Sokoto goats. *J. of Animal Production Research (Nigeria)* 4(2):145–152.

Ministry of Agriculture Agricultural Statistics 1990. Gaborone, Botswana.

Mohamed-Saleem M. A. and von Kaufinann R. 1989. A rapid survey of feeding regimes for draught cattle in Niger State, Nigeria. *ILCA Bulletin.* 33: 14–17.

Ntseane P.G. 1991. *Role* of *Small Stock to the Welfare* of *the Rural Family.* A paper presented at a workshop of Oasis Motel, October 4–8, 1991.

Snedecor G.W. and Cochran W.G. 1967. *Statistical Methods.* Iowa State University Press, Iowa, USA. 593 pp.

Tilley J.M.A. and Terry R.A. 1963. A two stage technique for the *in vitro* digestion of forage crops. J. *British Grassland Society* 18:104–111.

Van Soest P.J. 1982. *Nutritional Ecology* of *the Ruminant. O* & B Books, Corvallis, Oregon, USA. 374 pp.

Effet d'une complémentation de fanes d'arachide sur les performances de chèvres Tswana allaitantes et de leurs chevreaux après sevrage

Résumé

L'alimentation de saison sèche des petits ruminants est principalement basée sur les pâturages naturels. Cependant, ceux-ci sort mal utilisés par les animaux car ils sort pauvres en azote, en énergie et en sels minéraux. Cela réduit la productivité du bétail élevé sur ces pâturages. Une étude a donc été menée pour évaluer d'une part, l'effet d'une complémentation de fares d'arachide sur des chèvres Tswana allaitantes et d'autre part, l'effet de blocs urée mélasse donnés en combinaison ou non avec des fanes d'arachide sur les performances de chevreaux sevrés, élevés sur pâturage naturel pendant la saison sèche.

Trois groupes de 10 chèvres allaitantes âgées de 24 mois et ayant un poids initial de 37 kg ont été utilisées pour l'essai d'alimentation. Le premier groupe n'a reçu aucun complément alors que les groupes 2 et 3 ont reçu respectivement 300 et 600 g de fanes d'arachide par têté et par jour. La complémentation entraînait un poids final, un gain de poids moyen quotidien et une production laitère plus élevés ($P<0,001$).

Les performances après sevrage de chevreaux recevant les blocs uree-mélasse et les fares d'arachide étaient supérieures à celles des chevreaux recevant uniquement les blocs à 1écher. Une croissance compensatrice avait été enregistrée chez les chevreaux nés des chèvres du groupe témoin.

L'analyse de la rentabilité économique (en Pula (P)) a donnés des marges brutes de))-534P, -35P et +346P respectivement pour les chèvres recevant 0, 300 et 600 g de fanes d'arachide par jour. Ces résultats permettent de conclure que la complémentation alimentaire de chèvres allaitantes avec des fanes d'arachide est profitable pour les éleveurs possésdant au moins 9 chèvres en lactation.

Performance of weaner sheep fed wheat straw ensiled with caged layer waste

S.B. Kayongo, M.M. Wanyoike, P.N. Mbugua, T.E. Maitho and P.N Nyaga

Faculty of Veterinary Medicine, University of Nairobi
P. O. Box 29053, Nairobi

Abstract

The performance of weaner lambs fed for 90 days Rhodes grass hay alone (A) or supplemented with silages containing 0, 20 or 40% (B, C, D) caged layer waste (CLW) was examined. Weaver sheep on the diet of hay supplemented with 40% CLW silage had higher total DMI (P<0.01) and average daily gain (ADG) than sheep on the other treatments. Mean DMI/kg $W^{0.75}$ and ADG were 59.4, 58.7, 60.0 and 65.0 g/day and 15.0, 20.5, 17.6 and 33.2 g/day for treatments A, B, C and D, respectively. Carcass composition did not (P>0.05) differ between treatments except that kidney fat was lower (P<0.05) for sheep on the B silage diet. Dressing percentage, % lean, % fat were: 30.4, 31.4, 32.1 and 33.5, 58.0, 59.0, 58.9 and 58:5, 8.3, 7.2, 8.2 and 8.9% for treatments A, B, C and D, respectively. The study showed that CLW was a suitable protein supplement for sheep when processed by ensilage for 42 days at a level of 40% inclusion with wheat straw.

Introduction

The human population in Africa is expanding at an estimated rate of 4% per annum, thereby increasing the demand for protein from animal sources which calls for increased research into alternative sources of feed for livestock. Crop residues provide a source of roughage but their potential is limited by high fibre, low protein, mineral and vitamin content. Chemical treatment of crop residues has been found technically feasible but is of limited application in tropical Africa due to the high cost of the chemicals and insufficient know-how on the use of chemicals by small-scale farmers. The most practical and feasible method of improving the nutritive value of crop residues is through supplementation with energy and/or protein sources.

Caged layer waste is a rich source of protein ranging between 25–30% CP of which 40–50% is true protein. Poultry waste is available in urban and peri-urban areas of Kenya and has been successfully fed to lactating cows (Kayongo and Irungu 1986), beef steers (Odhuba et al 1986) and lactating goats (Nyakalo 1991). In the present study the nutritive value of caged layer waste ensiled with wheat straw and its suitability as a protein supplement for growing sheep were assessed.

Materials and methods

Caged layer waste was collected from 300 layer chickens of the Shavers type, aged 40 weeks and fed on Layers Mash. The waste which was composed of chicken faeces, spilled feed, broken eggs and feathers was collected every three days from a polythene sheet placed below the cages that housed the layers. Wheat straw was chopped in lengths of 2.5–5 cm, put in containers mixed with tap water at a rate of 1:1 by weight and left to stand overnight. Silos measuring 4 m ×2 m × 0.6 m were lined with 500 gauge polythene sheet on all sides and bottom. The moistened wheat straw was emptied into each silo in quantities of 100 kg fresh weight to which 3 kg molasses diluted with 31 of water was added. Caged layer waste was added at rates of 0, 20 and 40% by weight. All silos were opened after 42 days by uncovering a small portion (about 30 cm^2) to allow removal of the required quantity of silage.

Thirty-two entire Corriedale weaver lambs six to eight months old of age and weighing 14.9–25.0 kg liveweight were used in the study. They were weighed at the start of the study and thereafter once weekly before feeding. After an adaptation period of four weeks, during which the sheep were individually fed Rhodes grass *(Chloris gayana)* hay and 200 g of commercial Dairy Meal per sheep per day, they were divided into four blocks with two animals per block. The blocks were assigned at random to four treatments in a complete block randomised design. The sheep were fed for 90 days on Rhodes grass hay alone or supplemented with silage containing 0, 20 or 40% CLW silage (treatments A, B, C and D), respectively. Water and Maclick mineral lick were offered *ad libitum*. Proximate analysis was carried out following AOAC (1984) procedures. *In vitro* digestibility of OM and DM of the feeds was determined by the two-stage procedure of Tilley and Terry (1963).

After 90 days four sheep from each treatment were slaughtered to determine carcass quality. The procedure followed was as described by Mafwere and Mtenga (1992). The dressed carcasses were chilled for 24 hours and the cold carcasses sawn down through the centre of the vertebral column. The left side of the carcass was separated into the fore and hind quarters and the l0th rib. Each cut was weighed and dissected into butcher's bone, muscle (lean) and fat.

Carcass analysis was performed to determined carcass weight, per cent tissue on the left-hand side (LHS) of the carcass; kidney fat weight; 10th rib weight and tissue composition. Data obtained were analysed using Harvey's Least Squares analysis programme (Harvey 1990). Differences between treatment means were tested with orthogonal contrasts.

Results and discussion

The chemical composition of hay and silage fed to the wearer sheep is shown in Table 1. Hay showed low crude protein (4.8%) and DM and OM *in vitro* digestibilities of 35 and 39.5%, respectively, and a high crude fibre content (40.8%). The composition of hay used in the present study compared favourably to that fed to beef steers by Odhuba et al (1986). However, it was poorer than that fed to wearer sheep by Mafwere and Mtenga (1992) which contained 5.9% CP and 38.0% CF. The hay used in the study was purchased commercially and its quality varied considerably because of source, stage of growth at harvest. Crude protein of silage was 3.6, 5.8 and 7.7% for silage containing 0, 20 and 40% CLW, respectively. The corresponding CF values of the silage were 48.2, 43.9 ad 41.6%. The 40% CLW-silage had 53.2% more CP and 15.9% less CF than silage alone. All the silage had low IVDMD and IVOMD, though the 40% CLW-silage had the highest values. This was expected since wheat straw has a high fibre content whereas supplementation with CLW would reduce this component and increase CP content of the mixture.

Table 1. *Chemical composition and* in vitro *digestibility of hay and silage fed to sheep.*

		Silage-CLW inclusion (%)		
Diet	Hay	0	20	40
Dry matter	89.0	24.5	24.0	25.3

Composition of dry matter,%				
Crude protein	4.8	3.6	5.8	7.7
Crude fibre	40.8	48.2	43.9	41.6
Ether extract	2.2	2.2	2.4	2.5
Ash	8.7	10.3	12.0	14.3
Organic matter	91.1	90.3	88.8	86.1
Nitrogen-free extract	43.5	35.7	35.9	33.9
In vitro digestibility,				
Dry matter	35.0	29.7	31.7	36.5
Organic matter	39.5	36.0	40.2	41.8

The composition of the silage was in agreement with the findings of Economides (1986) who reported that roughages ensiled with poultry litter had higher CP content compared to those without. Ensiling is reported to conserve the CP in CLW and some of the uric acid in the CLW is converted to true protein during the fermentation process (Economides 1986). The relative increase in digestibility with increasing level of CLW inclusion indicated an improvement in the nutritive value of the crop residues and is in agreement with the findings by Daniels et al (1983).

The results of feed intake and utilisation by the wearer lambs are shown in Table 2. Sheep on the control diet consumed 25% more ($P<0.01$) hay than those on silage diets. Sheep on the 40% CLW consumed (8–10%) more DM/kg $^{0.75}$ than sheep on the other treatments. dry matter intake increased as the level of CLW in the silage increased and this was accounted for by the increase in CP and decrease in CF content. These changes could have increased digestibility which in turn have led to increased rate of passage of the silage feeds through the gut. Ensiling has also been shown to reduce the objectionable odour associated with raw CLW and this could have improved its acceptability to wearer sheep (Okeke and Oji 1991). The reduced hay dry matter intake with increasing silage dry matter intake suggested that silage depressed intake of hay probably because of a substitution effect. The observations from the present study were in agreement with those reported by Ariel et al (1991) who observed that animals fed on crop residues ensiled with poultry litter had higher DM intake than those fed crop residues ensiled alone.

Table 2. *Least square means of performance parameters of weaver sheep fed silage diets.*

	Hay	Silage + % CLW			
Parameter	0 (A)	0 (B)	20 (C)	40 (D)	SEM
Daily dry matter intake, kg/day	0.6^{a}	0.6^{a}	0.6^{a}	0.7^{b}	0.01
Hay intake/day, kg	0.4^{b}	0.3^{a}	0.3^{a}	0.3^{a}	0.01
Hay + silage intake/day, kg	0.4^{a}	0.4^{a}	0.4^{a}	0.5^{b}	0.01
Silage intake/day, kg	–	0.l^{a}	0.l^{a}	0.2^{b}	0.01
Dry matter intake, g/kg Lwt	27.6^{a}	27.4^{a}	28.2^{a}	29.8^{b}	0.32
Hay intake, g/kg Lwt	19.2^{b}	13.3^{a}	13.5^{a}	14.5^{a}	0.30
Hay + silage intake g/kg Lwt	19.2^{a}	18.8^{a}	19.3^{a}	21.8^{b}	0.34
DM intake, g/kg W $^{0.75}$	59.4^{a}	58.7^{a}	60.0^{a}	65.0^{b}	0.72

Hay intake, g/kg $W^{0.75}$	41.6^a	28.6^a	28.9^a	31.8^a	0.67
Hay + silage intake, g/kg $W^{0.75}$	41.6^a	40.2^a	41.1^a	47.5^b	0.76
Initial body weight, kg	20.9	20.0	19.6	21.0	0.29
Final body weight, kg	21.8^a	21.2^a	20.6^a	22.7^b	0.17
Average daily gain, g/day	15.0^a	20.5^a	17.6^a	33.2^b	5.52
Feed intake/kg Lwt gain	5.0	4.9	7.4	7.2	2.80

ab Means bearing similar superscript within a row are not different (P>0.05).

Average daily gain (ADG) of sheep on 40% CLW silage was significantly (P<0.01) higher than that of sheep on the other treatments (Table 2). These higher liveweight gain and final liveweight of sheep on the 40% CLW silage suggested that CLW improved the nutritive value of wheat straw. This could be accounted for by the higher crude protein content and *in vitro* digestibility of that diet compared to the other diets (Table 1). The relatively better performance of sheep on the control than those on the 0 and 20% CLW level indicated that this diet was superior to the unsupplemented wheat straw. This was expected since the hay was higher in nutritional value than the wheat straw (Table 1).

The observations in the present study are in agreement with those reported by McClure and Fontenot (1987) who fed yearling steers either on maize grain (1 body weight) or maize forage ensiled with 30% (DM basis) of turkey or broiler manure. However, the results of the present study differed from those reported by Economides (1986) and Rodrigues et al (1987) who did not record any superior performance by animals fed crop residues ensiled with CLW. The discrepancies between these results could be attributed to the use of poultry waste containing litter by those workers as opposed to uncontaminated CLW used in the present study.

The level of CLW inclusion in the silage did not (P<0.05) affect feed conversion ratios (Table 2). This observation suggested that wheat straw/caged layer waste silage gave a poor feed conversion. This was attributed to the low dry matter content of the silage coupled with the high ash content of CLW which would lower the DE of the silage. The results of the present study were in agreement with those reported by Rodrigues et al (1987) who showed that feed required per unit of gain was increased in animals fed rations containing poultry waste.

The level of CLW inclusion had no (P<0.05) effect on slaughter characteristics of the sheep, except kidney fat which was lowest in sheep fed the unsupplemented wheat straw (Table 3). Dressing percentage was highest for the sheep on treatment D and lowest for those on the control. Hot carcasses from sheep on treatment D were 10.3, 15.5 and 7.7% heavier than those on treatment A, B and C, respectively. Total lean, total fat and total bone did not (P>0.05) differ among treatment means. Nonetheless, sheep on the 40% CLW silage had 10.9, 17.4 and 6.5% more lean and 37.5, 37.5 and 25% more fat than sheep on treatments A, B and C, respectively. The 10th rib weight increased marginally (P>0.05) with higher levels of CLW inclusion. The higher kidney fat of sheep on treatment D was consistent with the higher tissue fat content of the sheep on that treatment. The correlation between kidney fat and carcass fat was high and significant (r = 0.61). The rather low dressing percentage of the sheep could be attributed to the age of the animals, and this was consistent with the low fat content of the carcasses.

Table 3. *Slaughter characteristics and carcass composition* of *weaner sheep fed silage.*

Parameter	Hay	Silage +%CLW			SEM
	(A)	0 (B)	20 (C)	40 (D)	
Liveweight, kg	22.3[a]	20.98[a]	22.4[a]	23.2[b]	0.17
Hot carcass weight, kg	7.0	6.6	7.2	7.8	0.33
Dressing percentage	30.4	31.4	32.1	33.5	0.88
Tissue in carcass, kg					
Total lean	4.1	3.8	4.3	4.6	0.27
Total fat	0.5	0.5	0.6	0.7	0.06
Total bone	2.5	2.2	2.4	2.5	0.13
Tissue in LHS,					
Lean	58.0	59.0	58.9	58.5	1.57
Fat	8.3	7.2	8.2	8.9	1.18
Bone	33.1	32.6	32.5	31.5	1.41
Composition of LHS, %					
Forequarters	48.4	50.1	49.6	49.4	1.95
Hindquarters	46.9	48.2	48.4	49.0	0.68
10th rib, g	60.7	58.7	62.0	63.7	3.15
Tissue in 10th rib%					
Lean	64.1	67.0	64.3	64.3	5.49
Fat	4.5	2.7	3.3	3.3	1.06
Bone	32.6	28.9	30.6	32.2	2.55
Kidney fat, g	86.5[a]	53.5[b]	85.7[a]	96.2[a]	8.44
Tissue ratios in carcass					
Lean:fat	7.9	7.4	6.9	5.9	0.82
Lean:bone	1.6	1.8	1.7	1.9	1.09
Lean + fat:bone	2.1	2.4	2.4	2.5	0.13

ab Means bearing similar superscript within a row are not significantly different (P>(1.05).

Nonetheless, the findings of the study concurred with those reported by Odhuba et al (1986) and by McClure and Fontenot (1987) on beef steers and on wearer calves, respectively, fed poultry litter enriched silage diets. Similar results were recorded by Rodrigues et al (1987) on sheep fed a control diet or those fed diets containing 10, 20 or 30% poultry litter.

Conclusions

The results showed that caged layer waste was a suitable supplement for growing sheep when ensiled with wheat straw at a level of 40% inclusion and fermented for 42 days. There was significant increase in DMI and ADG, whereas carcass composition was not adversely affected.

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References

AOAC (Association of Official Analytical Chemists). 1984. *Official Methods of Analysis.* 14th ed. AOAC, Washington, DC,USA.

Arieli A., Pecht Y., Zamweli S. and Tagari H.1991. Nutritional adaptation of heifers to diets containing poultry litter. *Nutr. Abstr. Rev.* 61:4388.

Daniels L.B., Smith M.J., Stallup O.T. and Rakes J.M. 1983. Nutritive value of ensiled broiler litter for cattle. *Anim. Feed Sci. Technol.* 8:19–24.

Economides 5.1986. By-products utilization in ruminant diets in Cyprus. In: Preston T.R. and Nuwanyakpa M.Y. (eds), *Towards Optimal Feeding* of *Agricultural By-products to Livestock in Africa. Proceedings of a Workshop held at the University* of *Alexandria, Egypt, October 1985.* ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 61–67.

Harvey W.R.1990. *Users Guide for LSML 1990. Mixed Model Least Square and Maximum Likelihood Computer Programme.* Ohio State University, Columbus, Ohio, USA.

Kayongo S.B. and Irungu K.R.G. 1986. Evaluation of broiler waste in formulation of concentrate for lactating Friesian heifers grazing irrigated pasture. *E. Afric. Agric. For. J.* 52:9–15.

Mafwere W.D. and Mtenga L.A. 1992. Lablab *(Dolichos niger)* meals as protein supplement for weaned lambs. In: Rey B., Lebbie S.H.B. and Reynolds L. (eds), *Small Ruminant Research and Development in Africa. Proceedings of the First Biennial Conference of the African Small Ruminant Research Network; Nairobi, Kenya, 10–15 December 1990.* ILCA (International Livestock Centre for Africa), Nairobi, Kenya. pp. 375–386.

McClure W.H. and Fontenot J.P. 1987. *The Relative Value of Turkey and Broiler Litter Ensiled with Corn Forage and Finishing Weaning Calves.* Anim. Sci. Res. Rep. Virginia Agricultural Experimental Station. pp. 80–82.

Nyakalo S. 1991. Effect of feeding poultry waste based diets on milk products from Galla goats. MSc thesis, University of Nairobi, Nairobi, Kenya. 141 pp.

Odhuba E.k., Magadi J.P. and Sanda T.A. 1986. Poultry waste in cattle rations. 1. Utilization of broiler litter as a source of nitrogen in semi-intensive feedlot rations. E *Afric. agric. For. J.* 52:16–21.

Okeke G.C. and Oji U.I. 1991. The nutritive value of grass ensiled with cassava peels and poultry excreta for goats. *Nutr. Abstr. Rev.* 61:26–71.

Rodrigues C., Rondon Z. and Parra R. 1987. Use of poultry litter for feeding lambs. *Nutri. Abstr. Rev.* 60:871.

Tilley J.M.A. and Terry R.A. 1963. A two-stage technique for the *in vitro* digestion of forage crops. *J. Brit. Grassl. Soc.* 18:104–111.

Performances d'agneaux sevrés recevant de la paille de blé ensilée avec des déjections de pondeuses en batteries

Résumé

Les performances d'agneaux sevrés nourris pendant 90 jours de foin de *Chloris gayana* seul (A) ou complémenté avec de la paille de blé ensilé avec 0, 20 ou 40 % (B,C,D) de déjections de pondeuses en batteries ont été examinées. L'ingestion totale de matière sèche et le gain moyen quotidien (GMQ) des agneaux recevant 40% de déjections étaient supérieurs (P<0,01) à ceux des animaux soumis aux autres traitements. L'ingestion moyenne de matière sèche par kg de $P^{0.75}$ était de 59,4; 58,7; 60 et 65 g/j et le GMQ de 15; 20,5;17,6 et 33,2 g/j respectivement pour les traitements A, B, C et D. Les caractéristiques de la carcasse n'étaient pas significativement différentes (P>0,05) entre les rations si l'on excepte le fait que le gras de rognon était plus important (P<0,05) chez les agneaux recevant la ration B que chez les autres animaux. Les rendements à l'abattage et les pourcentages de maigre et de graisse étaient de 30,4; 31,4; 32,1; et 33,5; 58; 59; 58,9; et 58,5; 8,3; 7,2; 8,2 et 8,9% respectivement pour les traitements A, B, C et D. On peut conclure que les déjections de pondeuses constituent un bon compliment protéique pour les agneaux lorsqu'elles sont ensilées à 40% avec de la paille de blé pendant 42 jours.

Complémentation de *Setaria splendida* avec *Mimosa scabrella* chez les chevreaux de race locale au Rwanda

P. Kamatali[1], *J. Ugeziwe*[2] *et A. Niang*[2]

[1]Précédemment à l'Université nationale du Rwanda,
B.P. 117, Butaré (Rwanda)

[2]Précédemment au Centre international pour la recherche en agroforesterie (ICRAF)
et à l'Institut des sciences agronomiques du Rwanda (ISAR)
B.P. 138, Butaré (Rwanda)

Résumé

Une étude sun les effets de la complémentation de *Setaria splendida* avec *Mimosa scabrella* dans l'alimentation de la chèvre commune rwandaise a été réalisée à la station de recherche de Gakuta au Rwanda en mars-avril 1993 sun 24 chevreaux de race locale, âgés de 6 mois et pesant en moyenne 12 kg. Ces chevreaux ont été répartis en 3 lots homogènes de 8 chevreaux chacun recevant respectivement des rations composées de S. *splendida* seul, de 67% de *S. splendida* + 33% de *M. scabrella* et de 34% de *S. splendida* + *66*% de *M. scabrella.*

Les résultats obtenus indiquent que comparativement à la ration *S. splendida* seal, la quantité de matière sèche ingérée a augmenté de 11% avec la ration contenant 67% de *S. splendida* + *33*% de*M. scabrella* (626 g/j de MS ingérée). Ce taux d'ingestion est beaucoup plus élevé(P<0,05) que celui obtenu avec la ration contenant 34% de *S. splendida* + *66*% de *M. scabrella* (593 g/j). Par ailleurs, pour les taux d'incorporation de *M. scabrella* de 33 et 66%, les gains moyens quotidiens obtenus étaient respectivement supérieurs à 51 et 64%, taux qui n'étaient pas significativement différents (P>0,05).

Introduction

Au Rwanda, l'élevage caprin joue un rôle de plus en plus important dans les zones densément peuplées suite à la diminution constante des pâturages disponibles. Pourtant, le potentiel de production des caprins nest pas pleinement exploité du fait de l'existence de diverses contraintes parmi lesquelles l'alimentation figure au premier rang. L'élevage caprin constitue la meilleure spéculation pour les petites exploitations. Sur le plan économique, 65% des chèvres sont vendues sun les marchés tandis que les 35% restants sont destinés à l'autoconsommation (Ministère de l'agriculture, de l'élevage et des forêts, 1988).

C'est dans le but de contribuer à l'amélioration de l'alimentation de la chèvre commune rwandaise (Small East Africa Goat, Murayi *et al.,* 1987) que cet essai de complémentation de *Setaria splendida*avec *Mimosa scabrella* a été entrepris. *Mimosa scabrella* constitue une essence agroforestière bien appétée (Ugeziwe, 1993), produisant une biomasse importante, récemment introduite au Rwanda et bien adaptée aux sols acides des hautes fences de la Crête Zaïre-Nil. C'est donc une ressource fourragère importante pour les petits ruminants à condition de déterminer les taux optima d'incorporation daps les rations à base de fourrages de qualité médiocre.

Matériels et méthodes

L'étude a été réalisée en mars-avril 1993 à la station de recherche de Gakuta au Rwanda, à 2400 m d'altitude, avec des moyennes annuelles pour la pluviométrie de 1553 mm et pour la température de 14,6 °C.

Le matériel animal étudié était constitué de 24 chevreaux de race locale âges de 6 mois et pesant en moyenne 12 kg. Il a été réparti en 3 lots homogènes de 8 chevreaux chacun.

Du point de vue régime alimentaire, les fourrages vents de *S. splendida* et *M. scabrella* ont été récoltés, mélangés et offerts aux animaux le jour même de la coupe selon les rations suivantes:

Ration I*: S. splendida* seal

Ration II: 67% de *S. splendida* + *33*% de *M.scabrella*

Ration III: 34% de *S. splendida* + *66*% de *M. scabrella.*

La composition chimique moyenne des fourrages est présentée au tableau 1. Les animaux étaient nourris *ad libitum* (plus de 10% de refus) deux fois par jour, à 9 heures et à 16 heures. Ils disposaient en permanence d'eau et de pierre a lécher. Les refus étaient retirés et pesés avant la distribution du repas du matin pour calculer les ingestions journalières des deux types de fourrages.

Tableau 1. *Composition chimique moyenne de* S. splendida *et de* M. scabrella *servis aux chevreaux (en % de matière sèche).*

Espèce	MS (% de MV)	Cellulose brute	Matière organique	Protéines brutes	Matières grasses	K	Mg	Ca	P
S. splendida	19,59	26,24	91,57	6,97	3,29	0,76	0,26	0,18	0,23
M. scabrella	25,00	19,00	96,22	25,00	7,03	0,62	0,19	0,44	0,22

MS: matière sèche; MV: matière verte.

L'essai a duré 36 jours dont 15 jours d'adaptation et 21 jours d'expérimentation proprement dite. Le dispositif expérimental utilisé est complètement aléatoire (3 rations réparties aléatoirement daps 3 lots homogènes d'animaux).

Les résultats expérimentaux sont obtenus par traitement statistique avec utilisation du logiciel SAS.

Résultats et discussion

Comparativement à *S. splendida* servi seal, la quantité de matière sèche totale ingérée a augmenté de 11% avec l'incorporation de 33% de *M. scabrella* dans la ration à base de *S. splendida.* Ce taux d' incorporation a permis de meilleures ingestions de matière sèche (626g/j de MS ingérée) par rapport au taux d'incorporation de 66% (593 g/j, $P<0,05$). Ces résultats conferment ceux obtenus par Rhodes et Udén (1990) avec *Leucaena* comme complément du foin.

En ce qui concerne les gains de poids vif (tableau 2), l'incorporation de *M. scabrella* a accru de manière considérable les gains moyens quotidiens (GMQ) des chevreaux, donnant des accroissements de 51 et 64% respectivement pour les taux d'incorporation de 33 et 66%. La différence entre ces deux taux n'est cependant pas significative (P>0,05) en ce qui conceme les gains moyens quotidiens. Par rapport à la ration à base de *S. splendida* seal, une meilleure injection de matière sèche totale dans les rations complémentées s'explique par la richesse en matière azotée totale de ces rations.

Tableau *2.* *Ingestions et gains de poids* vif *moyens quotidiens (GMQ*)*des chevreaux recevant* S. splendida *complementé avec* M. scabrella.

Ration	Ingestions de MS totale (g/têt/j)	GMQ (g/j)
S. splendida seul	563,5 b	31,2 b
S. splendida + 33% *de M. scabrella*	625,6 a	47,1 a
S. splendida + 66% *de M. scabrella*	593,3 ab	50,9 a

a,b Les valeurs portant la même lettre ne présentent pas de difference significative

Le taux d'incorporation de 66% de *M. scabrella* a des effets dépressifs sur l'ingestion de matière sèche totale. Par ailleurs, on n'a pas enregistré d'amélioration significative dans les gains moyens quotidiens. D'autres essais devraient être réalisés pour déterminer le taux optimal d'incorporation, ainsi que les causes de l'effet dépressif des taux d'incorporation supérieurs à 66% sur l' ingestion de la matière sèche totale chez les chevreaux.

Ces causes seraient probablement liées aux substances chimiques contenues dans le *M. scabrella* telles que le tanin, le phénol, etc. (Reed *et al.,* 1990)

Conclusion

Mimosa scabrella constitue une source d'éléments nutritifs intéressante pour les petits ruminants. La complémentation de *Setaria splendida* avec des feuilles et tiges tendres de *Mimosa scabrella* a amé1ioré les ingestions de matière sèche totale. Cependant, le taux d'incorporation de 33% a permis une meilleure ingestion (626 g/j) comparé au taux de 66% (593 g/j) et au *S. splendida* seul (563 g/j). D' autres essais sont nécessaires pour déterminer le taux d'incorporation de *M. scabrella* dans les diverses rations à base de fourrages de qualité médiocre.

Bibliographie

Ministère de l'agriculture, de l'élevage et des forêts, Rwanda. 1988*.* Programme de relance du secteur agricole. Etude du sous-secteur d'élevage. Kigali (Rwanda).

Murayi T., Sayers A.R. et Wilson R.T. 1987*. La productivité des petits ruminants dans les stations de recherche de l'Institut des sciences agronomigues du Rwanda.* Rapport de recherche n° 15*.*CIPEA (Centre international pour l'élevage en Afrique), Addis Abeba (Ethiopie). 58 p*.*

Reed J.D, Soller H. et Woodward A. 1990*.* Fodder tree and straw diets for sheep: intake, growth, digestibility and the effects of phenolics on nitrogen utilisation. *Animal Feed Science and Technology*30:39–50*.*

Rhodes N.M. et Udén P.1990*.* Effect of supplementing mature grass hay with dried *Leucaena* leaves on organic matter digestibility and voluntary intake by sheep. *Animal Feed Science and Technology* 31:1–8*.*

Ugeziwe J. 1993. Etude de l'appétibilité et de l'ingestibilité de huit essences agroforestières adaptées à la région des hautes altitudes de la crête Zaïre-Nil. Mémoire de fin d'études, faculté des sciences agronomiques, Université nationale du Rwanda (Rwanda).

Supplementation of *Setaria splendida* with *Mimosa scabrella* fed to the Small African Goat in Rwanda

Abstract

A feeding experiment was carried out in March–April 1993 at Gakuta Research Station in Rwanda to assess the effect of supplementation of *Setaria splendida* with *Mimosa scabrella* when fed to the Small East African Goats. Twenty-four 6 months-old kids weighing an average of 12 kg were allocated into three groups receiving, respectively, S. *splendida* alone, 33% *S. splendida* + 67% *M. scabrella* and 34% *S. splendida* + *66% M. scabrella.*

The results indicate that the dry matter intake of the group receiving 67% *S splendida* + 33% *M. scabrella* was 11% higher than the intake by the group receiving *S. splendida* alone, and was significantly higher (P<0.05) (629 g DM/day) than the intake of kids receiving 34% *S*. *splendida* + 66% *M. scabrella* (593 g/day). Compared to the weight gain of the group receiving *S*. *splendida*alone, the average daily weight gain was 51 and 64% higher, respectively, for the groups receiving 33% and 66% of *M*. *scabrella.* The difference of weight gain between the two last groups was, however, not significant (P>0.05).

Comparative studies on nutritive quality of Early- and late-heading varieties of Rhodes grass *(Chloris gayana)* and *Setaria (Setaria sphacelata)* in Kenya

J.E.E. Keveleng[1], A.B. Orodho[2] and R. Keigatti[3]

[1]Kenya Agricultural Research Institute (KARI), National Animal Husbandry Research Centre
P. O. Box 25, Naivasha, Kenya

[2]Regional Research Centre, P.O. Box 169, Kakamega, Kenya
[3]KARI, Beef Research Centre, P. O. Box 1275, Nakuru, Kenya

Abstract

Early- and late-heading varieties of *Chloris gayana* and *Setaria sphacelata* were evaluated to allow the selection of superior germplasm. Chemical constituents did not differ (P>0.05) between species or varieties within species except for cellulose and hemicellulose contents which showed differences within (P<0.05) but not between early- and late-heading varieties. *In vitro* digestibility values were significant between dates of cutting (P<0.01) but not between (P>0.05) varieties. In the *in vivo* trials significant differences (P<0.05) were observed in metabolisable energy (ME) and digestible crude protein (DCP) intakes and the resulting growth rates of sheep (P<0.05). Mean DM intake ranged from 29.1 to 53.2g/kgW $^{0.75}$/day or from 1.1% to 2.1% of body weight (BW) in Nasiwa setaria and Boma Rhodes, respectively. Mean DM digestibility varied from 59.6% for Elmba to 63.4% for Mbarara Rhodes.

DCP and ME intakes of the four Rhodes grass varieties met requirements for maintenance and growth whereas the two *Setarias* did not. Mean DCP and ME intakes ranged from 14.2g to 37.6 g/day/kg $W^{0.75}$ and from 4.1 MJ to 9.2 MJ/day for Nasiwa *Setaria* and Boma Rhodes, respectively. Mean daily gain of sheep ranged from 146 g to 244.5 g/day when fed Elmba Rhodes or Boma Rhodes. The early-heading varieties were superior to their respective standard late-heading one.

Introduction

Rhodes grass *(Chloris gayana*) and *Setaria* (*Setaria sphacelata*) are among the most widely cultivated pasture grasses in Kenya. Bogdan (1977) attributed their wide adoption as livestock fodder to their high seed and dry matter (DM) yields, sward persistence, pure germinating seed content (PGS) and the resulting ease of establishment. Boonman (1977) and Van Wijk (1976) emphasised seed yield, and therefore bred early-heading varieties of *Chloris gayana* and *Setaria sphacelata* for the improved agronomic and sward characteristics: e.g. early-heading, early maturity, increased biomass and PGS. However, these improved early-heading varieties were not evaluated as feeds against later-maturing ones; hence both types have continued to be used in sown pastures found in livestock farming systems in Kenya.

Minson and Milford (1966) and Javier (1975) argued that digestible energy intake combined with other nutritive values were necessary when evaluating forage mixtures and making comparisons between forage species. Similarly, Akin'Ova (1975) concluded that measurements of animal performance were essential during preliminary assessments of herbage quality.

Crowder and Chheda (1982) and Butterworth (1985) reported a wide range in digestible energy and protein content in tropical forages. These differences in nutritive quality often explained the variation in animal intake and performance. Hence, the recording of animal performance together with digestible energy and protein intake are a necessary part of the evaluating process.

Materials and methods

A series of evaluation trials were conducted on early and late-heading varieties of *Chloris gayana* and *Setaria sphacelata* to determine superior ecotypes of high nutritive value and animal performance. The trials were carried out at the National Agricultural Research Centre (NARC), Kitale, Kenya. NARC is situated at 1 °01'N and 35°00'E at an altitude of 1890 m asl. Mean annual rainfall is about 1170 mm with a bimodal distribution; mean temperature is 18.3°C and mean relative humidity ranges from 90% to 50% at 0900 and 1500 h, respectively. Soils are well drained reddish loam, but deficient in macro-elements. The centre represents the medium-altitude high-potential areas of Kenya.

The early-heading *C. gayana* cv Boma, and cv Elmba, *S. sphacelata* cv Nasiwa and late-heading *C. gayana* cv Mbarara, *C. gayana* cv Masaba and *S. sphacelata* cv Nandi were grown in a field layout of a randomised complete block (RCB) replicated four times. Standard recommended agronomic practices, basal P at the rate of 40 kg P_20_5/ha, 100 kg N/ha as CAN were applied in three split doses and 2–4D (72% a.i.) was sprayed to eradicate broad-leafed weeds. The grasses were mowed in the subsequent seasons before the onset of the rains and top dressed with 40 kg N/ha CAN. Herbage was harvested at 4, 6, 8 and 10 weeks stages of growth from randomly selected 1-m^2 quadrats in consecutive growing seasons during three years.

Composite samples were stored after oven-drying at 60°C for 48 hours. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were analysed according to Goering and Van Soest (1970). Nitrogen (N) was determined using the semi-micro Kjedahl analysis (Markham 1942). Samples for ash and silica determinations were dry ashed overnight in a muffle furnace at 400°C.

In vitro OMD values were determined by two stage technique of Tilley and Terry (1963). For *in vivo* digestibility studies, six wether sheep balanced for age and weight were randomly assigned to each block where each sheep was fed either an early- or late-heading variety *ad libitum.* The feeding trial consisted of a preliminary and collection period lasting 10 and 45 days, respectively. Water and mineral licks were provided *ad libitum.* Liveweight (LW) measurements were taken weekly to calculate average daily gains (ADG). Digestibility (D-values) of the grasses was assessed during the last 15 days of each feeding trial. Procedures by Steel and Torrie (1960) were used in statistical analyses.

Results

Mean organic structural composition and apparent nutrient digestibility are presented in Table 1. The results gave differences in cellulose and hemicellulose contents within (P<0.05) but not between (P>0.05) the two types of varieties. Significant differences (P<0.01) could not be established for the other nutrient constituents. D-values differed significantly (P<0.05) within but not between early-heading and standard late-heading varieties. Dry matter (DM), crude protein

(CP) and gross energy (GE) digestibility were different within (P<0.01) and between variety (P<0.05). Digestible crude protein (DCP) and digestible energy (DE) were different (P<0.05) within and between variety types.

Table 1. *Average chemical composition, apparent digestibility and digestible nutrients of six grass varieties.*

	Varieties						
	Rhodes grass				Setaria		
Variables	Elmba early	Boma early	Mbarara late	Masaba late	Nasiwa early	Nandi late	SE
Composition of dry matter, % DM							
NDF	74.1	71.6	70.3	77.1	72.3	72.6	2.5
ADF	45.3	41.3	38.9	44.5	48.8	46.5	3.2
Cellulose	36.4	34.8	32.2	38.6	42.6	40.7	2.3
Hemicellulose	30.2	30.3	31.3	32.9	23.4	26.5	1.6
Adl	7.7	6.9	6.8	7.8	6.2	5.8	1.0
Silica	2.1	2.2	3.3	1.8	1.6	1.9	0.7
CP	6.9	6.5	6.9	5.3	5.2	5.9	0.6
Apparent digestibility,%							
DM	59.6	62.4	63.4	62.1	60.1	61.9	1.0
CP	52.9	56.5	55.1	47.5	48.7	50.0	1.9
GE	53.7	53.7	59.1	59.3	53.4	61.7	1.2
Digestible nutrients	56.7	58.1	59.9	53.8	60.7	60.8	1.7
DCP, %	3.8	3.6	3.4	2.8	2.7	3.0	0.1
DE KJ/g	10.3	11.2	11.1	10.9	9.9	10.1	0.2

1 The data represent means of 4, 6, 8 and 10 weeks of growth over three seasons.

Mean nutrient intakes and performance wether sheep are summarised in Table 2. Mean intakes of DM, CP and digestible nutrients varied widely and were significant (P<0.05) within types but not (P>0.05) between types of varieties. The quantity of ME ingested depended directly on the amount of digestible dry-matter (DDM) intake and dietary ME concentration in each variety.

Table 2. *Mean intake of nutrients and performance by wether sheep fed varieties of* Chloris gayana *and* Setaria sphacelata.[1]

	Varieties						
	Rhodes grass				*Setaria*		
Variables intake	Elmba late	Boma early	Mbarara late	Masaba early	Nasiwa late	Nandi early	SE
Intake							
DM, g	892	1028	29	933	511	600	45
CP, g	62.3	6604	57.8	50.6	27.9	36.0	3.0

DM, g/kg $W^{0.75}$	48.0	53.2	43.4	48.1	29.1	35.4	1.9
DM, % WT	1.76	2.03	1.65	1.80	1.15	1.34	–
DDM, g	537	690	524	546	302	384	31
ME, MJ	7.6	9.2	7.4	8.3	4.1	5.0	0.4
Content							
ME, MJ/kg DM	8.6	9.0	9.6	8.9	8.1	8.3	–
DCP, g/kg DM	34.6	37.6	33.4	25.0	14.2	1.7	1.9
CP/ME, g/ME	8.2	7.2	7.8	6.1	6.8	7.2	
LW, kg	50.6	50.7	50.3	51.7	44.4	44.9	2.3
ADG,g	146	244	153	220	–146	–115	33

1 Means represent data for three seasons for each grass variety harvested at 4, 6, 8 and 10 weeks of growth.

ADG was influenced by varying quantities of available DCP and metabolisable energy (ME) intake. Among the Rhodes grass varieties, cv Boma was superior in all aspects: intake, nutrient content and growth of sheep. The other varieties differed little; a tentative ranking would be: cv Masaba > Elmba Mbarara. Nandi and Nasiwa setaria gave negative ADG, due to low nutrient content and the resulting intake.

The effects of stages of growth are shown in Table 3. Mean DM, DDM and ME intakes were not affected (P>0.05) by stages of growth. However, CP and DCP intakes declined rapidly (P<0.05) beyond six weeks of growth. ME concentration was not affected (P>0.05) by stages of growth. Protein-energy ratios declined steadily (P<0.05) from 4 to 10 weeks of growth. Growth of sheep declined with herbage maturity although differences were not significant.

Table 3. *Effects of stages of growth on mean intake of nutrients and performance of wether sheep on six grass varieties.*[1]

Items	Maturity age at harvesting (weeks)				SE
	4	6	8	10	
Intake					
DM, g	812	830	745	809	37 ns
CP, g	60.5	57.8	44.6	37.7	2.4
DM, g/kg$W^{0.75}$	44.4	44.5	39.5	43.0	1.6 ns
DM, % BW	1.69	1.70	1.53	1.64	
DDM, g	517	525	452	467	25.0 ns
ME	7.0	7.3	6.5	7.0	0.4ns
DCP, g	35.1	33.7	23.0	17.3	1.6
Content					
CP/ME, g/MJ	8.6	7.9	6.9	5.4	
ME, MJ/kgDM	8.9	8.8	8.8	8.7	
LW, kg	48.1	48.9	48.8	49.2	21.3 ns

ADG, g	216	149	176	143	27ns

Means represent data from three seasons for six grass varieties fed to six wether sheep. ns = non significant.

Discussion

The analysis of nutritive value showed that there were no consistent differences between species or between varieties within species because the structural components (NDF, ADF etc) varied between narrow limits. A similar conclusion can be drawn for digestibility of nutrients, except for crude protein, which was higher in Rhodes grass than in *Setaria*; the highest DCP content was found in the two early-heading Rhodes varieties.

Hacker and Minson (1972), Burton and Minson (1972), Crowder and Chheda (1982) reported that genetic differences in pasture species at variety level contribute towards differences in *in vivo*digestibility. Our comparisons between the early-heading and respective late-heading varieties do not confirm their observations except for CP. Thus, this apparent lack of differences at the variety level demonstrated that during the breeding process of early-heading varieties genotypes of parent grass varieties were not extensively manipulated to induce permanent changes in nutritive values.

In contrast to the *Setaria* varieties, the Rhodes grass ones provided sufficient DCP and ME for maintenance and growth in sheep (ARC 1980). The differences in animal growth between the four*Chloris* varieties were associated with the ME concentration, energy metabolisability, efficiency of nutrient utilisation and N degradability of the respective varieties. The observed weight losses may also be associated with low N degradability in *S. sphacelata* and confirmed the existence of genetic differences between species. The nutritive quality and animal performance demonstrated that early-heading and standard late heading varieties within species were not different in feeding values and animal performance. Pasture varieties that reached maturity age early are most suitable where short grazing cycles are advocated for increased animal intakes for digestible nutrients thereby improving animal productivity.

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References

ARC (Agricultural Research Council). 1980. *The Nutrient Requirements of Ruminant Livestock.* Commonwealth Agricultural Bureaux, Farnham Royal, London, UK.

Akeni'Ova M.E. 1975. *Improvement of* Pennisetum purpureum *Schum for Forage in the Altitude Humid Tropics.* PhD thesis abstracts, University of Ibadan, Nigeria.

Bogdan A. V. 1977. *Tropical Pasture and Fodder Planes. 1st* edition. Longman, London and New York. pp. 1–354.

Boonman J.G. 1977. *On Rhodes Grass Breeding, Seed Yields and Herbage Quality.* Technical Report GBP National Agricultural Research Station, Kitale, Kenya.

Burton G.W. Monson W.G. 1972. Inheritance of dry matter digestibility in Bermuda grass *(Cynodon dactylon* L. Pers.). *Crop Science* 12:375–378.

Butterworth M.H. 1985. *Beef Cattle Nutrition and Tropical Pastures.* Longman Group Limited, England.

Crowder L.V. and Chheda H.R. 1982. *Tropical Grassland Husbandry.* Longman, London.

Goering H.K. and Van Soest P.J.1970. *Forage Fibre Analyses. (Apparatus, Reagents, Procedures and Some Applications).* Agricultural Handbook 379. ARS, United States Department of Agriculture, Washington, DC, USA.

Hacker J.B. and Minson D.J. 1972. Varietal differences in *in vitro* dry matter digestibility in Setaria and the effects of site and season. *Australian Journal of Agricultural Research* 23: 959–967.

Javier E.O. 1975. Breeding for quality forage. *Extension Bulletin 50.* ASPAC Food and Fertilizer Technical Centre, Taiwan. pp. 1–29.

Markham R. 1942. A steam distillation apparatus suitable for micro-Kjeldahl analysis. *Biochemistry Journal* 36:790–791.

Minson D.J. and Milford R. 1966. The energy values and nutritive value indices of *Digitaria. Journal of Agricultural Research* 17:411–423.

NARS (National Agricultural Research Station), National Agricultural Research Station, Kitale. Annual Reports Reprints of 1953–1979. Ministry of Agriculture, Kenya.

Steel R.G.D. and Torrie J.H.1960. *Principles and Procedures of Statistics.* McGraw-Hill Book Co. Inc., New York, USA.

Tilley J.M.A. and Terry R.A. 1963. A two stage technique for the *in vitro* digestion of forage crops. *Journal of British Grassland Society* 18:104–111.

Van Wijk A.J.P. 1976. Herbage yield and quality relationships of three varieties of *Setaria sphacelata* (Schumach, Stapf and Hubbard). *Netherlands Journal of Agricultural Science* 24:147–154.

Etudes comparatives de la valeur nutritive de variétés à épiaison précoce et tardive de *Chloris gayana* et de *Setaria sphacelata* au Kenya

Résumé

Des variétés à épiaison précoce et tardive de *Chloris gayana* et de *Setaria sphacelata* ont été évaluées en vue de la séléction de matériel génétique de haute qualité. La comparaison des composantes chimiques n'a pas révélé de différence significative (P>0,05) ni entre les espèces, ni entre les variétés au sein dune même espèce, excepté pour les teneurs en cellulose et en hémicellulose pour lesquelles il y avait des différences au sein des varietés (P<0,05) mais pas entre celles à épiaison précoce et celles à épiaison tardive (P>0,05). Les paramètres de digestibilité *in vitro* variaient significativement en fonction de la date de la coupe (P<0,01), mais pas en fonction de la variété (P>0,05). Dans les essais *in vivo,* il y avait des différences significatives (P<0,05) pour l'ingestion d'énergie métabolisable et de protdines brutes digestibles, et les taux de croissance associés des ovins (P<0,05). La consommation moyenne de matière sèche (MS) variait de 29,1 à 53,2 g/j/kg de $P^{0.75}$ ou de 1,1 à 2,1 % du poids vif, respectivement pour les cultivars Nasiwa de *S*. *sphacelata* et Boma de *C*. *gayana.* Le taux moyen de digestibilité de la MS allait de 59,6 à 63,4% respectivement pour les cultivars Elmba et Mbarara.

L' ingestion de matures protéiques brutes et d' énergie métabolisable des quatre variétés de *C*. *gayana* permettait de couvrir les besoins d'entretien et de croissance des animaux, ce qui était loin d'être le cas pour les deux variétés de *S*. *sphacelata.* La consommation moyenne de matières protéiques brutes et d'énergie métabolisable variait de 14,2 a 37,6 g/j/kg de $P^{0.75}$ et de 4,1 A 9,2 MJ/j respectivement pour les cultivars Nasiwa et Boma. Quant au gain moyen quotidien (GMQ) des ovins, il allait de 146 à 244,5 g/j, selon qu'ils recevaient le cultivar Elmba ou Boma de *C. gayana.* Les variétés à épiaison précoce étaient supérieures aux variétés standard à épiaison tardive correspondantes.

Use of sweet potato *[Ipomea batatas (l.)* Lamb] vines as starter feed and partial milk replacer for calves

A.B. Orodho, B. O. Alela and J. W. Wanambacha

Kenya Agricultural Research Institute, Regional Research
Centre, P.O. Box 169, Kakamega, Kenya

Abstract

Sweet potatoes *(Ipomea batatas)* are a common tuber crop on smallholder farms in Kenya. Although mainly grown for human consumption, the vines are frequently harvested as livestock feed to supplement low quality grazing or cut-and-carry grass herbage in smallholder dairy farms to increase milk yields of cows and growth of calves. Its use was evaluated when fed *ad libitum* to calves to act as a milk replacer to augment the amount of milk for sale.

Twenty-five Friesian calves were randomly allocated to five treatments in which groups were fed diminishing quantities of milk over a range from 415 to 211 kg over 100 days, while having *ad libitum*access to sweet potato vines. Growth rates of calves declined from 425 g/d at lowest to 506 g/d at the highest milk intake (P>0.05).

A single vine harvest yielded 2.4 t DM/ha and did not differ (P>0.05) between the two varieties tested; 30% of the forage consisted of leaf, 24% of petiole and the remainder was stem. crude protein content averaged 17.5% for whole vines, while leaf contained 30% CP compared with 10% in the other plant components. Fibrocity of leaf and petiole was relatively low (ADF 22% and 28%, respectively) which together with the high moisture content (80–90%), suggests that vines are a suitable milk replacer, making sweet potato an ideal dual-purpose crop for smallholder farmers who rely on daily sales of milk as their main source of steady cash income.

Introduction

The majority of the dairy farmers in Kenya are smallholders many of whom keep cattle in a semi-zero grazing management system. These farmers produce about 75% of the total milk (MoALD 1983). Good dairy cows are expensive and often difficult to obtain. Most farmers therefore rear their own calves which are their major source of replacement stock. Calves are fed on limited amounts of whole milk and grazing; supplements are not fed because of high prices and the scarcity of commercial feeds in local markets. In most small farms, milk is the major steady source of income and therefore there is a tendency to restrict milk feeding to calves. Following a survey of 106 dairy farms, Kiragu (1993) indicated that calves suffered high mortality (18–20%) and had low growth rates (less than 300 g/ day). Stotz (1979) attributed this poor performance of calves to poor feeding and management practices.

The low level of forage feeding to stock is a major constraint to milk production and calf performance. Napier grass *(Pennisetum purpureum)* is a high yielding forage crop grown by nearly all small dairy farmers that practice zero or semi-zero-grazing. Other forages may include Guatemala grass *(Tripsacum laxum),* Giant Panicum *(Panicum maximum),* Rhodes grass *(Chloris gayana)* and*Setaria* grass *(Setaria sphacelata).* The quality of these forages fluctuate with varying phenological stages of growth and are lowest during the dry season.

Calves raised in cut-and-carry systems are mainly fed Napier grass of low quality, particularly during dry season or when harvested at a height of 1 metre or more.

Sweet potatoes *(Ipomea batatas)* are grown by small-scale livestock farmers as a dual-purpose crop; the vines are fed to livestock whereas the tubers are used for human food (Karachi 1982; Orodho 1990). In Kenya, two cultivars of sweet potatoes, namely Musinyamu and Toilo, are most commonly grown. As a supplement to low-quality roughage, feeding sweet potato vines increases intake and the rate of liveweight gains of weaners (Karachi et al 1990). Semenye and Hutchcroft (1992) found no significant difference in growth between kids weaned on sweet potato vines and kids that received all the milk from their dams. The value of sweet potato vines is attributed to high yield, palatability and crude protein content. These characteristics coupled with the high moisture content make fresh sweet potato vines an effective milk replacer. Thus, young livestock fed vines can be weaned early, thereby making sizeable quantities of milk available for home consumption or for sale. The main objective of this study was to evaluate sweet potato vines as starter feed and partial milk replacer when fed to unweaned heifer calves.

Materials and methods

The trial was conducted at the Regional Research Centre, Kakamega (0.17°34'N and 35°00'E) located at an altitude of 1558 m asl. The average mean annual rainfall is 1960 mm with a bimodal distribution. Average evapotranspiration is 1490 mm with a mean sunshine duration of 8.1 hrs. The average mean temperature is 20.5°C and mean relative humidity ranges from 64% at 0600 to 52% at 1200 h. The soils are well-drained, deep, dark reddish brown friable nitisols with a humic top and moderately deficient of macro elements. The Centre represents medium altitude high potential areas where small scale farming is common.

The two varieties Musinyamu and Toilo were planted in one hectare of uniform land in separate fields. Disease free vines were planted at a spacing of 40 cm between rows and 30 cm between plants. Planting materials were pieces of vine at least 30 cm long, cut from the lower end, 20 cm of which was buried in the soil. Fields were kept weed-free at all times. Yields were estimated by cutting eight random samples (1 m^2) for each variety. From the harvested samples, a subsample was taken and separated into leaf blades, leaf petioles and stems (runners). Fresh forage materials were oven-dried at 60°C for 48 hours and ground in a Wiley mill to pass through a 40-mesh screen. The ground samples were kept in sealed plastic bags to await laboratory analysis.

Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were analysed according to the procedures by Goering and Van Soest (1970). Nitrogen (N) was determined using a Kjeldahl semi-micro digester (Markham 1942). Dry samples were ached in a muffle furnace at 400°C overnight for ash and silica determination.

Twenty-five Friesian heifers were allocated to five treatments in a completely randomised block design. All calves were fed *ad libitum* on colostrum for three days from birth and thereafter on varying quantities of raw milk as indicated in Table 1. The calves were fed *ad libitum* chopped fresh sweet potato vines and Napier grass except those in control Treatment 5 where sweet potato vines were omitted. Live weight (LW) was recorded weekly to calculate average daily gains (ADG). Procedures by Steel and Torrie (1960) were used in statistical analyses.

Table 1. *Daily milk consumption per calf by treatment (kg/d).*

Duration	Treatment				
	TI	T2	T3	T4	T5
Day 4–7[a]	2.0	2.5	3.0	3.5	4.0
Week 2	2.0	2.5	3.0	3.5	4.0
Week 3–9	3.0	3.5	4.0	4.5	5.0
Week 10–11	2.0	2.5	3.0	3.5	4.0
Week 12–13	1.0	1.5	2.0	2.5	3.0
Week 14–15	0	0.5	1.0	1.5	2.0

a Colostrum on day 13.

Results and discussion

Table 1 shows the daily milk consumption for the five treatments. Treatment 5 is the milk feeding schedule from birth to weaning as recommended in Kenya. Because of the high milk demand for both home consumption and sale, few smallholder farmers feed their calves according to this schedule. Across the four treatments (1–4), the potatoe vines replaced between 204 and 51 kg of milk (Table 1). Calves gained weight from 425 g/d at lowest, to 506 g/d at highest level of milk intake. However, there was no significant difference in average daily gains between treatments (Table 2). When the initial weights of calves were added for covariance analysis (i.e. to adjust all heifers to same initial weight) again no significant difference between treatments was found.

Table 2. *Effect of milk consumption (kg over 100 days) on the average daily gain of Friesian calves fed* ad libitum *Napier grass and sweet potato vines.*

Parameters	Treatment				
	1	2	3	4	5[a]
Total milk fed, kg	211	451	313	364	415
ADG, g/day	425	262	488	494	506

There was no significant difference in ADG (P>0.05).

a Control calves fed only Napier grass.

This confirms that sweet potato vines offered as an alternative to milk did not markedly affect the average daily gains of calves. Thus, a substantial amount of milk can be saved when sweet potato vines are fed as milk replacer. Sweet potato is a suitable milk substitute because of its chemical composition which compares well with that of milk.

Semenye and Hutchcroft (1992) working with dual purpose goats found that sweet potato vines met the requirement of kids when fed 30 g DM per kg of body weight per day. The chemical composition of milk and vines were comparable; milk had a moisture content of 85% and digestibility of 86% compared to 80% and 72% respectively in fresh vines. Similar results emerged from the current sweet potato trial.

There was no significant difference in harvested yield between the Musinyamu (2.47 tons/ha/harvest) and Toile variety (2.44 tons/ha/harvest), even though the two cultivars were markedly different in leaf colour and shape. Content of crude protein (CP), nutrient detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) for the two varieties were similar (Table 3), although cv Musinyamu had a slightly higher average fibre content than Toile. Since calves preferred leaf blades with CP contents of 24–26% to leaf petioles and stems with CP values of 8–12%, vines provided adequate CP in the calf diet. On average, leaf blades of cv Musinyamu contained more potassium, calcium and phosphorus than cv Toile (Table 3). Considering that only one-third of vine yield consisted of leaves, it is expected that other plant parts will be consumed by calves.

Table 3. *Yield and quality of two varieties of sweet potato vines at first harvest.*

	Musinyamu				Toilo			
Variables	Leaf	Petiole	Stem	Whole	Leaf	Petiole	Stem	Whole
Yield, tons DM/ha	0.78	0.52	1.17	2.47	0.71	0.63	1.10	2.44
Moisture content, %	81.8	93.0	84.5	86.4	81.1	90.6	85.4	85.6
%CP	26.3	8.0	8.4	18.5	24.1	12.1	10.2	16.6
%NDF	35.6	29.4	48.6	42.0	35.5	28.1	51.3	35.7
%ADF	22.0	28.8	39.2	29.3	21.6	2.3	41.5	26.2
%ADL	6.2	2.7	6.8	6.6	6.2	2.7	7.2	5.2
%K	4.8	7.5	5.5	5.6	3.0	8.6	4.8	5.3
%Ca	0.9	0.8	0.5	0.7	0.6	0.8	0.5	0.5
%P	0.5	0.3	0.3	0.4	0.3	0.4	0.4	0.4

Apart from reducing protein content, intake of other nutrients is unlikely to be reduced and potassium intake may increase. Due to a higher content of cell wall (NDF), cellulose and lignin (ADF and ADL), DM digestibility may be slightly reduced, when calves are forced to consume petioles and stems. Work done in Maseno (Semenye and Hutchcroft 1992) showed that sweet potato vines yielding 14.1 ton/DM ha per year and containing 16% crude protein and 80% moisture, with an *in vitro* dry matter digestibility of 74%: i.e. suitable herbage for young calves.

Conclusions

Sweet potato vines were found to be a high quality feed for calves. Their value is attributed to high yield, palatability and crude protein content. No significant differences were found between calves fed the recommended quantity of milk and those fed less milk and *ad libitum* sweet potato vines. Therefore sweet potato vines can partially replace milk, because its chemical composition, moisture content and digestibility are comparable to milk. Smallholder farmers may save up to half the amount of milk currently fed to calves for domestic use or sale provided they have enough sweet potato vines to feed.

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References

Goering N. K. and Van Soest P. J. 1970: *Forage Fibre Analyses (Apparatus, Reagents, Procedures and Some Applications).* Agricultural Handbook 379. USDA, (Dep't of Agriculture), Washington, DC, USA. 20 pp.

Karachi M. K.1982. The performance of sweet potato *(Ipomea batatas* (L.) Lamb) in Western Kenya 1. Effect of nitrogen and phosphorus combinations on yield 2. Yield of 31 cultivars E. *Afric. Agric. and For. J.* 47(3):55–59; 60–67.

Karachi M. K. and Dzowela B. H.1990. The potential of sweet potato *(Ipomea batatas* (L.) Lamb) as a dual purpose crop in semi-arid crop/livestock systems in Kenya. In: PANESA/ARNAB (Pastures Network for Eastern and Southern Africa/African Research Network for Agricultural By-products), *Utilisation of Research Results on Forage and Agricultural By-product Materials as Animal Feed Resources in Africa. Proceedings of the First joint Workshop held in Lilongwe. Malawi, 5–9 December 1988.* PANESA/ ARNAB, Addis Ababa, Ethiopia pp. 518–532.

Kiragu J. W. 1993. *Feeding, Management and Diseases of Young Calves.* Paper presented to the 4th Animal Production Research Scientists, at Mombasa, 23–26 October 1993. KARI (Kenya Agricultural Research Institute), Nairobi, Kenya.

MoALD. 1983. Ministry of Agriculture and Livestock Development Annual Report. Kenya Government.

Orodho A. B. 1990. Dissemination and utilisation of research technology on forages and agricultural by-products in Kenya In: PANESA/ARNAB (Pastures Network for Eastern and Southern Africa/African Research Network for Agricultural By-products), *Utilization of Research Results on Forage and Agricultural By-product Materials as Animal Feed Resources in Africa Proceedings of the First joint Workshop held in Lilongwe, Malawi, 5–9 December* 1988. PANESA/ ARNAB, Addis Ababa, Ethiopia. pp. 70–90.

Stotz D. 1983. *Production Techniques and Economics of Smallholder Livestock Production Systems in Kenya.* Farm Management Handbook of Kenya, Vol. 4. Ministry of Livestock Development, Animal Production Division, Nairobi, Kenya. 140 pp.

Steel R. G. and Torrie J. N. 1980. *Principles and Procedures of Statistics: A Biometrical Approach.* 2nd ed. McGraw-Hill Book Co, New York, USA.

Semenye P.P. and Hutchroft T. 1992. *On farm Research and Technology for Dual purpose Goats.* SR-CRSP, Nairobi, Kenya. 144 pp.

Van Soest P. J. 1982. *Nutritional Ecology of the Ruminant Metabolism, Nutritional Strategies, Cellulolytic Fermentation and the Chemistry of Forage and Plant Fibres.* O and B Books, Corvallis, Oregon, USA.

Utilisation de fares de patate douce *[Ipomea batatas* (L.) Lamb] comme aliment de démarrage et de substitution partielle du lait chez les veaux

Résumé

La patate douce *(Ipomea batatas)* est une tubercule cultivée couramment chez les petits paysans et destinée surtout à la consommation humaine. Ses fanes sont fréquemment utilisées dans les petites exploitations laitières comme aliment du bétail pour complémenter le fourrage de qualité médiocre ou celui des graminés, servi à l'auge, afin d'améliorer la production laitière des vaches et la croissance des veaux. Cette étude évalue l'utilisation de ces fanes données *ad libitum* comme aliment de substitution du fait chez les veaux afin d'accroître les quantités de lait destines à la vente.

25 veaux de race Frisonne ont été divisés au hasard en 5 groupes recevant pendant 100 jours des quantités décroissantes de lait allant de 415 à 211 kg, ainsi que des fanes de patate douce à volonté. Les GMQ des veaux ont diminué de 425 g/j (pour les rations à faible proportion de lait à 506 g/j (pour les rations à forte proportion de lait (P>0,05).

Une seule récolte de fanes a doné 2,4 t de MS/ha mais il n'y avait pas de différence significative (P>0,05) entre les deux variétés étudiées. Le fourrage se composait de 30% de feuilles, 24% de pétioles et le reste de tiges. La teneur en protéines brutes de l'ensemble de la plante était en moyenne de 17,5% contre 30% pour le feuillage et 10% pour les autres parties de la plante. La teneur en fibres des feuilles et des pétioles était relativement faible (respectivement 35% et 29% de fibre NDF), ce qui signifie que les fanes de patate douce, avec leur taux d'humidité élevé (80–90%),constituent un bon produit de substitution du lait, faisant ainsi de cette plante une culture à double fin idéale pour les petits exploitants pour qui la vente quotidienne de lait représente la principale source de revenu.

Use of groundnut hay and groundnut cake as supplements to Gambian N'Dama heifers exposed to trypanosomiasis

D.L. Romney[2], A.N. Jie[1], D. Clifford[1], P. Holmes[3], D. Richard[4] and M.Gild[2]

[1]International Trypanotolerance Centre, P.M.B. 14, Banjul, The Gambia
[2]Natural Resources Institute, Chatham Maritime, Chatham, Kent, ME4 4TB
[3]University of Glasgow Veterinary School, Bearsden Road, Glasgow, G61 1 QH
[4]Centre de coopération internationale en recherche agronomique pour le développement
2477 Avenue du Val de Montferrand, BP 5035, 34032 Montpellier, Cedex 1, France

Abstract

Thirty-two N'Dama heifers were offered *ad libitum Andropogon* hay plus 10.2 g/kg LW groundnut hay (GNH) (L) or 10.2 g/kg LW GNH and 3.9 g/kg LW groundnut cake (GNC) (H). After four weeks on diet, half of each group were inoculated intradermally with *Trypanosoma congolense* clone (ITC 50) (LI and HI). Peak parasitaemia occurred 6–8 days after inoculation and started to decrease approximately 56 days later. No differences in parasitaemia levels were observed between LI and HI animals. GNH and GNC intakes were maintained during the trial, however, infected animals decreased ($P<0.05$) intakes of *Andropogon* hay. LI animals lost significantly ($P<0.001$) more weight during the experimental period than their non-infected controls (–71.4 cf –13.7 g/day). Meanwhile, HI animals gained less weight ($P<0.001$) compared to H (52.2 cf 167.6 g/day). Weight losses appeared to be accounted for by decreased intakes of the forage part of the diet. PCV levels fell in all treatments (by 5.4,13.8, 3.7 and 9.4 units after 49–63 days p.i. for L, LI, H and HI groups, respectively) and significant effects of infection and diet were observed ($P<0.001$). Digestibilities did not differ significantly either between diets or with infection. It is concluded from the results that strategic use of locally available supplements can alleviate the effect of trypanosomiasis, although forage intake may be depressed.

Introduction

Murray (1987) suggested that one of the most important factors affecting the susceptibility of trypanotolerant animals to infection with trypanosomiasis is the nutritional status of the host. A study with sheep suggested that as plane of nutrition declines, the degree of trypanotolerance may decline (Reynolds and Ekwuruke 1988) and in cases of extreme nutritional stress N'Dama cattle are unable to control the anaemia caused by the disease (J. Bennison. personal communication). Previous studies carried out in the Gambia have shown that the severity of infection in grazing cattle can be reduced by supplementing with small amounts of concentrate feed (Agyemang et al 1990; Little et al 1990). Agyemang et al (1990) found that supplemented cattle recovered more rapidly from anaemia, while Little et al (1990) showed that PCV levels in animals on a lower plane of nutrition declined more rapidly than those on a higher plane. Little et al (1990) also suggested that the efficiency of nutrient utilisation was impaired in infected animals. However, in the former study, intake of the grazed part of the diet was not measured.

Under village husbandry systems in the Gambia, farmers do not normally supplement cattle, except for some saved groundnut hay (GNH) to oxen. However, GNH and oilseed cakes such as groundnut and sesame are available locally (Little et al 1991). In the present study N'Dama heifers were offered *Andropogon* hay supplemented with GNH or GNH plus groundnut cake (GNC) and the effects on intake, digestibility and pathogenesis of the disease determined.

Materials and methods

Thirty-two N'Dama heifers, aged 1–2 years, ranging in liveweight from 89–146 kg were used. Animals were allocated to four treatments, two groups (L and LI) receiving *ad libitum Andropogon* hay and GNH, while the remaining groups (H and HI) received an additional supplement of GNC. Diets were introduced to the animals over a two week period followed by a four week adaptation period. At the end of the sixth week, animals in groups LI and HI were inoculated intradermally with *Teleria congolense* clone (ITC 50). A standard pour-on, bayticol, was applied on a monthly basis to prevent cross infection from external parasites. Measurements were continued until sixteen weeks post infection (p.i.) when infected animals were treated with diminazine aceturate (Berenil) at 7 mg/kg LW.

Feed composition is presented in Table 1. Hay was fed hand chopped to a length of approximately 20 cm and fed *ad libitum* at 130% of the previous days intake. GNH was offered at 10.2 g/kg LW and GNC at 3.9 g/kg LW according to the mean LW of the animals in each group.

Table 1. *Composition of the feeds offered.*

Feed	Feed composition (% DM)					ME[1](Mj/kgDM)
	DM	OM	CP	ADF	NDF	
Andropogon hay	95.8	95.2	2.3	50.1	78.5	7
Groundnut hay	94.6	94.0	7.8	45.4	50.9	10
Groundnut cake	94.3	94.9	46.4	18.0	12.7	14

1 Values are estimates from feed tables.

Animals were individually tethered, 3 m apart in a fenced area. GNH and GNC were offered at 0900 h and *Andropogon* hay at 1000 h. Water was offered at 1200 h and 1500 h daily. Each animal had access to a mineral block *ad libitum.* Intakes of feed and water were measured daily and weekly sub-samples of feeds and refusals taken for analysis of crude protein (CP) and ash. Animals were weighed once weekly. Blood samples were taken three times weekly for determination of PCV using the standard micro-haematocrit method and parasitaemia using the dark ground huffy coat method (Murray et al 1977).

On three occasions during the trial, 24–20 days pre-infection and 20–24 and 62–66 days p.i., faecal grab samples and refusals for individual animals were collected over a 5-day period. Samples were analysed for DM and ash and apparent digestibility estimated. On days 16, 25 and 68 p.i., activity (eating, ruminating, idling) was recorded over a 24-hour period.

Statistical analysis

In order to compare the effect of diet and infection on intakes, liveweight and PCV, treatment means over two 14-day periods were calculated (140 days pre-infection and 493 days p.i.). Mean values within each period as well as liveweight changes over the whole of the p.i. period were compared using analysis of variance, separating effects due to diet and infection. In each of the digestibility periods, organic matter digestibilities (OMD) were examined in the same way. Mean parasitaemia levels in each week were compared using the standard error of difference.

Results

Animals in all treatments consumed all GNH and GNC offered throughout the trial. Changes in intake of *Andropogon* hay during the course of the experiment are shown in Figure 1, while Table 2 presents mean values for intakes in the two periods: –14–0 days pre-infection and 493 days p.i. Intakes of hay before infection were not significantly different between groups, but were lower (P<0.05) in infected animals during the p.i. period. Mean reduction in intake after 49–63 days was greater for the HI compared to the LI group (36 cf 17% of pre-infection intakes), although the difference was not significant. Furthermore, HI animals began to recover intakes after 10 weeks p.i., whereas depressed intakes were observed in LI animals until three weeks later.

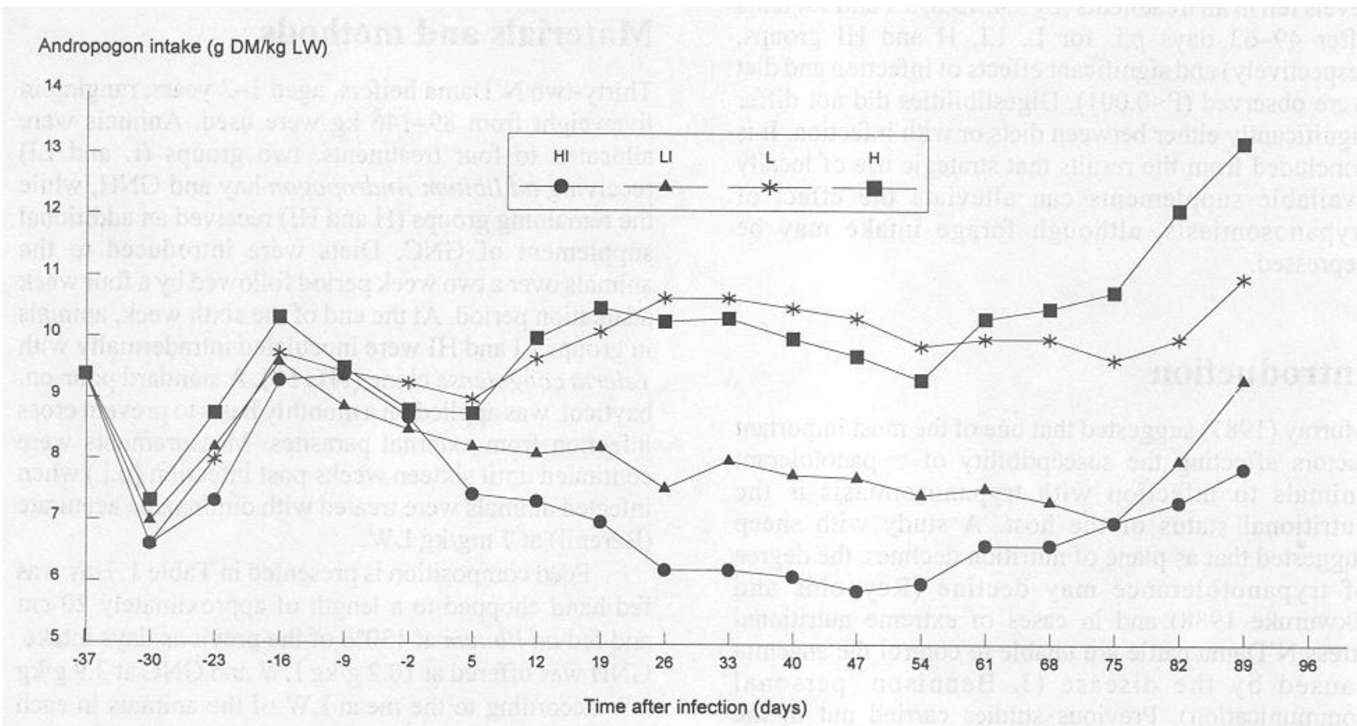

Figure 1*. Mean intakes of* Andropogon *hay before and after infection with* T. congolense.

Table 2. *Mean liveweights, intakes and CP content of the diet, before (–14–0 days) and after infection (49–63 days).*

	Diet composition				Pooled SE
	L	LI	H	HI	
Pre-infection (14–0 days)					
Mean LW (kg)	112	111	115	116	1.72
Hay intake (g DM/kg LW)	9.7	9.2	9.9	9.4	0.36
Total DM intake (g/kg LW)	19.2[a]	18.9[a]	22.3[b]	52.3[b]	0.35
CP content of diet (% DM)	5.1[a]	5.2[a]	11.7[b]	11.7[b]	0.15

Post-infection (49–63 days)					
Mean LW (lg)	110[a]	107[a]	118[b]	118[b]	1.70
Andropogon intake (g DM/kg LW)	10.1[a]	7.6[b]	6.0[b]	6.0[b]	0.53
Total DM intake (g/kg LW)	20.0[a]	17.8[b]	18.7[b]	18.7[b]	0.51
CP content of diet (% DM)	5.0[a]	5.5[b]	13.7[d]	132.7[d]	0.23

Means within the same row with different superscripts are significantly different (P<0.05).

Liveweight changes are presented in Figure 2. Animals on low levels of supplementation lost weight while those receiving the additional supplement of GNC gained weight. LI animals lost significantly (P<0.001) more weight following infection p.i. than their non-infected controls (–71 cf –14 g/day).

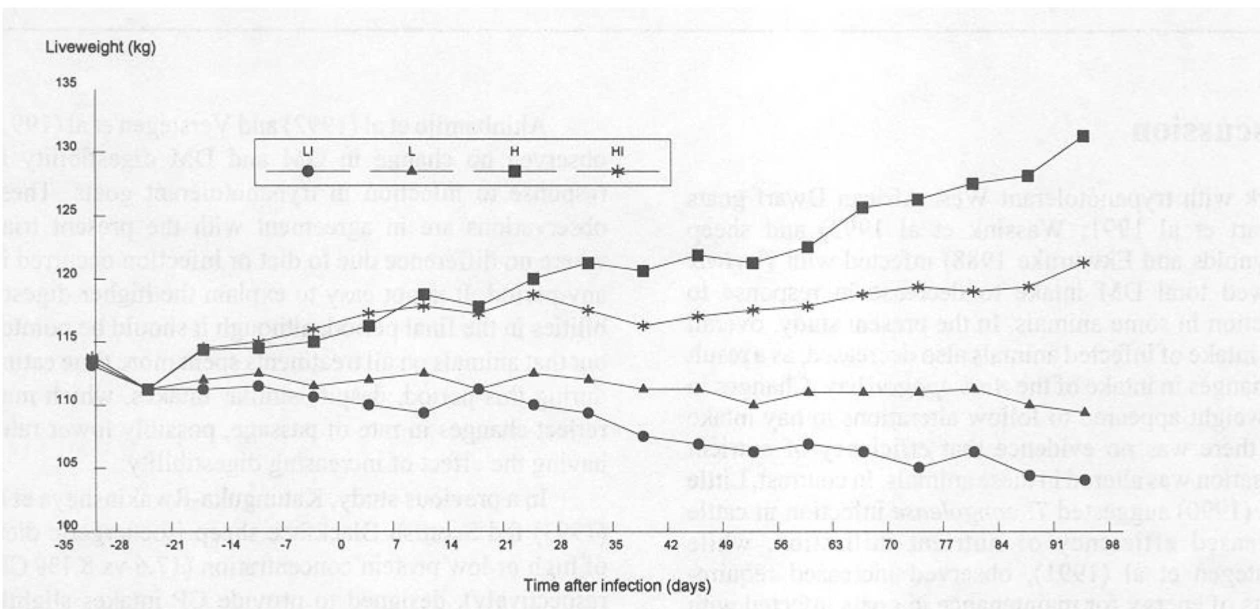

Figure 2. *Mean liveweights before and after infection with T.* congolense.

Meanwhile, HI animals gained less weight (P<0.001) than H group controls (52 cf 168 g/day). However, actual liveweights at 46–63 days p.i. were not greatly affected by infection, though they were significantly increased (P<0.01) by supplementation (see Table 2).

PCV (Figure 3) levels fell in all treatments by 5.4, 13.8, 3.7 and 9.4 units after 493 days p.i. for L, LI, H and HI groups, respectively, and significant effects of both infection and diet were observed (P<0.001). The most severe drop in PCV level was observed in the LI group, though there was no significant interaction between diet and infection. Changes in mean parasitaemia are shown in Figure 4. No significant differences were observed between treatments. Animals in both groups were able to tolerate the disease and began to recover spontaneously, parasite numbers starting to fall, around 56 days p.i.

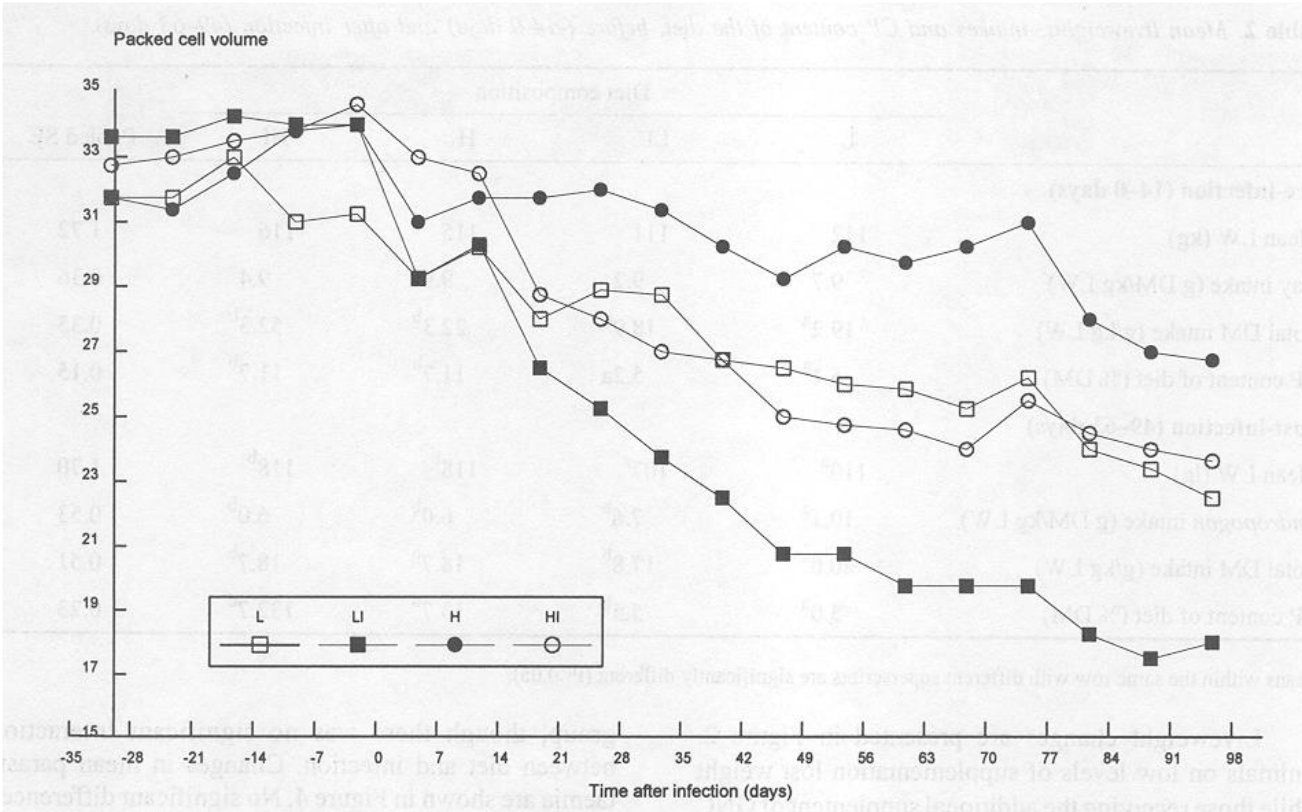

Figure 3. *Mean PCV levels in the blood before and after infection with T.* congolense.

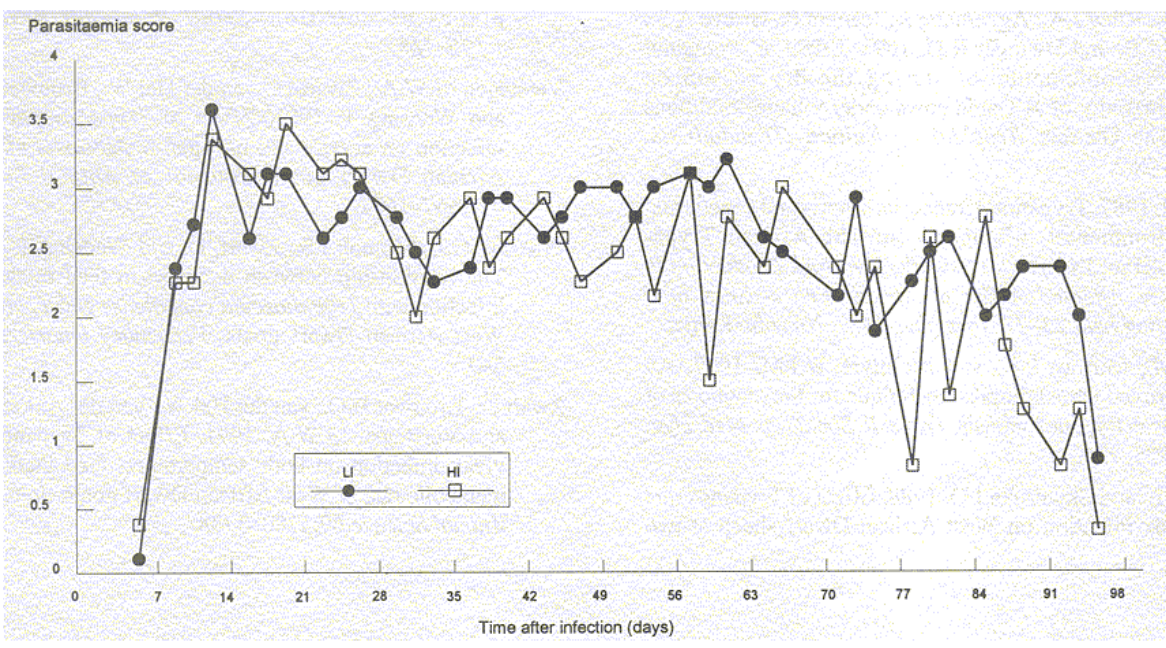

Figure 4. *Mean parasitaemia scores following infection with T.* congolense.

Digestibilities are presented in Table 3. No significant differences were observed in OM digestibility due to either infection or diet in any of the three measurement periods.

Table *3.* *Organic matter digestibility in animals on a high (H) or low (L) plane of nutrition, and infected animals on the same diets (HI, LI) measured 20–24 days pre infection, 20–24 and 62–66 days p.i.*

	Diet composition				Pooled SE	Significance
	L	LI	H	HI		
Pre-infection: 24–20 days	0.51	0.54	0.57	0.53	0.010	10
Post-infection: 20–24 days	0.52	0.52	0.59	0.53	0.010	ns
Post-infection: 62–66 days	0.58	0.59	0.59	0.60	0.008	ns

Means for intake during these periods were calculated, but are not presented here, since the trends were similar to those in the pre-and post-infection periods shown in Table 2.

Discussion

Work with trypanotolerant West African Dwarf goats (Zwart et al 1991; Wassink et al 1993) and sheep (Reynolds and Ekwuruke 1988) infected with *T. vivax* showed total DM intake to decrease in response to infection in some animals. In the present study, overall DM intake of infected animals also decreased, as a result of changes in intake of the *Andropogon* hay. Changes in liveweight appeared to follow alterations in hay intake and there was no evidence that efficiency of nutrient utilisation was altered in these animals. In contrast, Little et al (1990) suggested *T. congolense* infection in cattle decreased efficiency of nutrient utilisation, while Verstegen et al (1991), observed increased requirements of energy for maintenance in goats infected with *T. vivax*. Insufficient data were available to draw firm conclusions on this in the present study.

Akinbamijo et al (1992) and Verstegen et al (1991) observed no change in OM and DM digestibility in response to infection in trypanotolerant goats. These observations are in agreement with the present trial, where no difference due to diet or infection occurred in any period. It is not easy to explain the higher digestibilities in the final period, although it should be pointed out that animals on all treatments spent more time eating during this period, despite similar intakes, which may reflect changes in rate of passage, possibly lower rates having the effect of increasing digestibility.

In a previous study, Katunguka-Rwakinshaya et al (1993) fed Scottish Blackface sheep isoenergetic diets of high of low protein concentration (17.6 vs 8.1% CP, respectively), designed to provide CP intakes slightly below and above requirements for a liveweight gain of 120 g/day. Animals fed the high protein diet had significantly lower parasitaemia values during 16–70 days following infection with*T. congolense.* In the present trial no differences in parasitaemia levels were observed. However, it may be noted that CP concentrations in the diets used in our trial (approximately 11.5 and 5.2% of DM for H and L diets, respectively) were lower than those fed to the sheep. It may be that higher protein concentrations are required to affect parasitaemia levels.

PCVs dropped in both infected and uninfected animals. Although PCV values in the LI group were lower than in the HI group, there was no significant interaction between diet and infection on mean PCV values 49–63 days p.i. This agrees with observations in sheep infected with *T. vivax* by Katunguka-Rwakinshaya et al (1993) and Reynolds and Ekwuruke (1988), although in the latter work PCVs in some animals on a maintenance diet appeared to fall below levels observed in animals on a sub-maintenance diet.

In the present trial there was no firm indication that additional supplementation of infected animals assisted the mechanism for resisting disease. Effects of infection were similar on both L and H diets. This is in contrast to the work by Katunguka-Rwakinshaya et al (1993), where liveweight changes decreased in infected animals on low but not high protein intakes. In the work by Reynolds and Ekwuruke (1988), 80% of male sheep fed a sub-maintenance diet died following infection with *T. vivax*. In unpublished work from the Gambia, 10 out of 24 grazed cattle on sub-maintenance diets were withdrawn from trial as PCV levels fell below 15 (J. Bennison, personal communication). It may be that there is a critical level of nutrition, below which animals are no longer able to resist challenge with the disease, which was not reached in the present trial.

Conclusions

The results of the trial show that locally available by-products can be used to alleviate the symptoms of trypanosomiasis in trypanotolerant cattle.

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References

Agyemang K, Dwinger R.H., Touray B.N., Jeannin P., Fofana D. and Grieve A.S. 1990. Effects of nutrition on degree of anaemia and liveweight changes in N'Dama cattle infected with trypanosomes. *Livestock Production Science* 26:39–51.

Akinbamijo O.O., Hamminga B.J., Wensing Th., Brouwer B.O., Tolkamp B.J. and Zwart D. 1992. The effect of *T. vivax* infection in West African Dwarf goats on energy and nitrogen metabolism.*Veterinary Quarterly* 15:95–100.

Katunguka-Rwakinshaya E., Parkins J.J., Fishwick G., Murray M. and Holmes P.H.1993. The pathophysiology of *Trypanosoma congolense* infection in Scottish Blackface sheep. Influence of dietary protein. *Veterinary Parasitology* 47:189–204.

Little D.A., Dwinger R.H., Clifford D.J., Grieve A.S., Kora S. and Bojang M.1990. Effect of nutritional level and body condition on susceptibility of N'Dama cattle to *Trypanosoma congolense* infection in the Gambia. *Proceedings of the Nutrition Society* 49:209A.

Little D.A., Riley J.A., Agyemang K. Jeannin P., Grieve A.S., Badji B. and Dwinger R.H. 1991. Effect of groundnut cake supplementation during the dry season on productivity of N'Dama cows under village conditions in The Gambia. *Tropical Agriculture (Trinidad)* 68: 259–262.

Murray M.1987. Trypanotolerance, its criteria and genetic and environmental influences. In: The African Trypanotolerant Livestock Network, *Livestock Production in Tsetse Affected Areas of Africa. Proceedings of a meeting held 23–27 November 1987, Nairobi, Kenya.*

Murray M., Murray P.K. and McIntyre W.LM. 1977. An improved parasitological technique for the diagnosis of African trypanosomiasis. *Traps. R. Soc. Trop. Med. Hyg.* 71:325–326.

Reynolds L. and Ekwuruke J.O. 1988. Effect of Trypanosoma Vivax infection on West African Dwarf sheep at two planes of nutrition. *Small Ruminant Research* 1:175–188.

Verstegen M.W.A., Zwart D., van der Hel W., Brouwer B.O. and Wensing T. 1991. Effect of *Trypanosoma vivax* infection on energy and nitrogen metabolism of West African Dwarf goats. *Journal of Animal Science* 69:1667–1677.

Wassink G.J., Momoh LS., Zwart, D. and Wensing T. 1993. The relationship between decrease in feed intake and infection with *Trypanosoma congolense* and *T. vivax* in West African Dwarf goats.*Veterinary Quarterly* 15: 5–9.

Zwart D., Brouwer B.O., van der Hel W., van der Akker H.N. and Verstegen M.W.A. 1991. Effect of Trypanosoma vivax infection on body temperature, feed intake and metabolic rate of West African Dwarf goats. *Journal of Animal Science* 69:3780–3788.

Utilisation de fanes et de tourteau d'arachide comme compléments chez des génisses N'Dama exposées à la trypanosomiase en Gambie

Résumé

32 génisses N'Dama ont reçu à volonté du foin *d'Andropogon c*omplémenté avec 10,2 g de fanes d' arachide par kg de poids vif (faible niveau: F) ou cette même quantité avec 3,9 g de tourteau d'arachide par kg de poids vif (niveau éslevé: E). Au bout de quatre semaines de régime, le clône ITC 50 de *Trypanosoma congolense* a été inoculé à la moitié des animaux de ces deux lots (FI et EI) par voie intradermique. La parasitémie était maximum 6 à 8 jours après l'inoculation et a commencé à baisser après environ 56 jours. Aucune différence d'infection n'a été enregistrée entre les sujets des lots FI et EI. Les niveaux d'ingestion des deux rations se sont maintenus tout au long de l'essai, mais la consommation de foin *d'Andropogon* avait, diminué (P<0,05) chez les animaux contaminés. Les sujets contaminés recevant la ration à faible niveau ont perdu significativement plus de poids (P<0,001) au cours de la période d'essai que les animaux témoins non contaminés du même lot (–71,4 g/j contre –13,7 g/j). Quant aux sujets EI, ils ont gagné moins de poids (P<0,001) que ceux non contaminés du même lot (E) (52,2 g/j contre 167,6 g/j). Les pertes de poids semblent dues à la diminution de la consommation de la fraction fourragère de la ration. Les niveaux d'hématocrite opt baissé pour tous les traitements (de 5,4; 13,8; 3,7 et 9,4 unités entre 49 à 63 jours après le début de l'essai respectivement pour les lots F, FI, E et EI) et les effets de l'infection et du régime étaient significatifs (P<0,001). Les chiffres de digestibilité n'étaient pas significativement différents en fonction de la ration, que les animaux aient été contaminés ou non. Ces résultats montrent que

l'utilisation stratégique de compléments locaux peut atténuer l'effet de la trypanosomiase, même si l'on enregistre une baisse de la consommation fourragère.

Protein supplementation of grazing cattle in the semi-arid zone of Cameroon[1]

A. Njoya

Institute of Animal and Veterinary Research
P.O. Box 1073, Garoua, Cameroon

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Abstract

The effects of cottonseed meal (CSM) supplementation on forage dry matter intake (DMI), forage dry matter digestibility (DMD) and daily weight gain (ADG) of steers grazing natural pasture in the semi-arid zone of Northern Cameroon were determined during 120 days in the dry season and the residual effects were monitored during 120 days in the rainy season. Thirty steers (229 kg and 2.6 years) were randomly assigned to a randomised complete block design of three treatments (0, 0.5 and 1.0 kg of CSM per steer per day). After hand-feeding CSM to individual steers in the morning, all were allowed to freely graze a pasture dominated by *Andropogon* spp. Every month, two steers per treatment were put in digestion crates and fed hand-clipped *ad libitum* forage of similar botanical composition as that grazed by the remaining steers.

Cottonseed meal supplementation increased the amount of crude protein absorbed (CPA), rumen turn over rate (K_2) and average daily gain. Forage intake was increased only with feeding of 0.5 kg CSM. Forage dry matter and (NDF and ADF) digestibility (DMD) tended to decrease with 1.0 kg of CSM compared with 0.5 kg or no supplement. Cottonseed meal had no effect on cell wall (NDF and ADF) digestibility, DMD, CPA and ADG during the rainy season. Data from this study suggest that 0.5 kg of CSM can increase DMI, K_2, and ADG of cattle during the dry season and the extra gain improvement can be maintained throughout the rainy season.

These data and information from the literature were included in a simulation model to estimate the protein requirements for maintenance and to predict when feeding supplements to steers was economically beneficial. The simulation indicated that protein was insufficient to meet maintenance requirement of grazing steers during the dry season and part of the rainy season. Protein or nitrogen supplementation was required to prevent weight loss, and response could be expected to modest amounts of urea (50 to 60 g of urea per steer daily) whenever forage CP content was below 10%, which on average occurred from July to April.

Introduction

The low intake and depressed digestibility of tropical forages during dry periods have been attributed to high cell wall and low crude protein content (Minson 1971; Piot 1975; Butterworth 1985). Oilseed meals (cottonseed, groundnut and palm kernel meals) are widely produced in tropical Africa and can be used as sources of supplemental protein for grazing cattle. Several studies (Lhoste et al 1975; Piot 1975; Rippstein 1980) reported weight gain during the dry season when feeding 1 kg of cottonseed meal (CSM) per day to steers, whereas the unsupplemented steers lost weight. However, it was not clear whether the increased weight gain was due to the increased intake or higher digestibility, to the effects of protein or energy content of CSM supplement. The objective of this study was to determine the effects of different levels of CSM supplementation on intake and utilisation of pasture, on weight gain of steers, and when supplementation was beneficial financially.

Materials and methods

Study area

The study was conducted at the Animal Research Institute, Garoua in Northern Cameroon located in the Soudano-Sahelian zone (latitude is 9.3°N) at an altitude of 400 m asl and receiving an average annual rainfall of 993 mm.

Animals

Thirty steers with an average liveweight of 229 kg and 2 to 3 years of age were used. They were dewormed and treated for external parasites monthly during the dry season and twice monthly during the rainy season. Internal parasite control was repeated only at the beginning of the rainy season. Single injections of vitamins A, D^3 and E complex and a trypanomici were given prior to the start of supplementation. They were weighed once a month in the morning before feeding, having and access to natural pasture consisting mainly of *Andropogon gayanus* from 1 February until 1 October 1991.

Protein supplementation

Steers were blocked in 3 groups of 10, based on age and weight, then allotted to one of the 3 treatment groups: 0, 0.5 kg or 1.0 kg of CSM per head daily. In a large pen, steers received supplement while tethered to feeding stanchions. The CSM supplement (compositions: 95.8% DM, 40.8% CP, 14.6% NDF and 13.1% ADF, made of 95% CSM, 3.5% salt, 1.0% limestone and 0.5% mineral and vitamin premix) was individually fed in plastic dishes at 8 a.m. every day, from 1 February to 31 May. All steers were then put to graze together on natural pasture until 5 p.m. They were watered daily at 1200 h Mineral blocks (55% bone meal, 40% salt, 4% mineral and vitamin premix and 1% cement) were available to all animals in the night paddock.

Because supplemented animals were individually fed, and all grazed the same pasture, individual animals were considered as experimental units. Data were analysed as a complete block design, using the general linear model (SAS 1990). Sources of variations included period, treatment, block and the remainder as the error term. Treatment effects were tested by contrast comparisons (Cochran and Cox 1957).

Forage utilisation by steers

The effects of CSM supplementation in the dry season on forage intake (DMI) and digestibility (DMD) by steers were estimated each month from February to September. During the last 12 days of each month, six steers (two from each treatment chosen at random) were put into individual digestion crates made of wood and placed under an open-sided shed. Each period consisted of six days of adaptation and six days of collection. Forage was hand-harvested daily from the pasture being grazed by the remaining steers, making sure that its composition closely resembled that consumed by grazing steers. Forage intake was measured daily, in the mornings, before the next feeding. To allow herbage selection as is usually done by grazing cattle, forage was offered 30 to 50% above previous consumption and fed in 3 to 4 fractions between 8.15 a.m. and 4.00 p.m. Total faeces from each animal was collected twice and orts once a day, in the morning before feeding CSM. Forage was sampled three times during each collection period. Ten per cent of faeces and orts collected were sampled and frozen. Daily samples from each steer were mixed together to obtain one sample per steer per period. Faeces, orts and forage samples were dried at 60°C for 48 h, ground to pass a 2 mm screen, and saved for further analyses. At the end of the collection period, all steers were returned to the remaining herd. Nitrogen was analysed by Kjeldahl technique (AOAC 1984), neutral detergent fibre (NDF) and acid detergent fibre (ADF) by sequential method of Goering and Van Soest (1970).

Forage digests kinetics

These were measured each month, from April until September, using chromium (Cr) mordanted fibre (Uden et al 1980) containing 4.86% Cr. In the morning of the first day of the collection period, before feeding, 50 g of Cr-mordanted fibre was mixed with forage and fed to each steer. Faecal samples for the analysis of the marker were collected and frozen at 4, 8, 12, 18, 24, 36, 48, 60, 72, 96, 120 and 144 h post-feeding. They were dried at 60°C for 48 h, and ground to pass a 1 mm screen. Chromium concentration in faecal samples was determined in triplicates according to Williams et al (1962).

Digesta kinetics were determined by non-linear regression analyses (SAS 1990) of a two-compartment model (Pond et al 1984). No period x treatment interaction was noted for digestibility or digests kinetics parameters, so values were averaged over the four months of the dry season and the four months of the rainy season. Kinetics parameters were analysed by general linear model procedures (SAS 1990) and treatment effects were tested by contrast comparisons (Cochran and Cox 1957).

Simulation model

Using data from the grazing experiment, the eight *in vivo* and two *in situ* digestion trials and information from the literature, a simulation model was developed to estimate the energy and protein requirements for maintenance and to predict when feed supplements to grazing cattle was beneficial. The simulation program was written with Lotus 123^{R}.

Results and discussion

Effects of CSM supplementation during the dry season

Forage DMI increased 16% by 0.5 kg of CSM supplement (P =0.05), but 1.0 kg did not have any further effect. Feeding CSM tended to decrease forage DMD by steers (P = 0.09). This depression was greater (P = 0.05) when 1.0 kg of CSM was fed compared with feeding 0.5 kg of CSM meal. Feeding C SM increased total DMI (P = 0.02) and tended to increase total digestible DMI (P = 0.10). However, total DDMI was similar for the two supplemented groups. Total crude protein intake (CPI) and digestible CP content were enhanced (P = 0.0001) by supplementation. Cell wall intake tended to increase with supplementation (P = 0.07 for NDF and P = 0.04 for ADF), but its digestibility was depressed when 1.0 kg of CSM was fed compared with feeding 0.5 kg or none (Table 1).

Table 1. *Effects of cottonseed meal supplementation on forage intake and utilisation by steers on pasture during the dry season.*

	CSM, kg/d			
	0	0.5	1.0	SE[1]
Forage DMI, kg	3.0[a]	3.5[b]	3.0[a]	0.16
DMI, %	59[a]	58[a]	49[b]	3.3
Total DMI,g/W$^{0.75}$	58[a]	68[b]	72[b]	3.4
DDMI, g/W$^{0.75}$	35	42	42	3.4
CPI, g	146[a]	354[b]	550[c]	7.0
Digestible CPI, g	70[a]	240[b]	380[c]	9.0
NDFI, kg/d	1.95	2.30	2.10	0.11
NDFD, %	69	67	61	3.1
ADFI, kg/d	1.30[a]	1.57[b]	1.42[a]	0.07
ADFD, %	1.30[a]	1.57[b]	1.42[a]	0.07
K_2%/h	1.2	1.5	1.6	0.33
TMRT, h	120[a]	1.46[b]	100[b]	6.0
ADG, kg	0.10[a]	0.27[b]	0.27[b]	0.06

1 Standard error of least square means (n = 8).
abc Row means with different superscripts differ (P<0.05).

The depression in the digestibility of forage and cell wall with feeding 1.0 kg of CSM was probably due to a change in rumen microbial population. When fed at 0.5 kg/d, CSM supplement represented only 12.1% of the total DMI compared to 24.4% when 1.0 kg/d was fed. At this high level, CSM may have depressed the rumen pH and therefore reduced the cellulolytic microbes in favour of the proteolytic and amylolytic populations.

Hunter and Seibert (1980) observed a 38% increase in spear grass consumption without any depression in DMD when steers were supplemented with 0.4 kg of CSM. DelCurto et al (1990) also reported an increase in forage intake and digestibility by steers when fed moderate amounts of protein supplements; but higher amounts had no further effect. Higher amounts of protein supplements could replace part of forage intake, because of physical limitations of the digestive tract to handle larger amounts of DM. Crabtree and Williams (1971) found that protein supplementation of low quality forages has a synergistic effect when fed at a moderate level and a substitution effect when fed at above 25% of total DMI. Since feeding 1.0 kg of CSM did not increase forage DMI, but instead reduced digestibility it appears that 0.5 kg of CSM is the optimal amount for steers grazing low-quality pastures.

Forage digesta kinetics

The ruminal rate of passage of the digests (K_2) was 30% faster when CSM at either level was fed compared with the control and this was associated with a higher total DMI. The total mean retention time (TMRT) of the forage digests decreased (P=0.05) by CSM supplement. Thus, feeding 1.0 kg of CSM may have shortened the exposure time of forage to rumen microbial action and explains the decrease of DMD to 49.1% compared with 59.3% in the diet of the control steers. McCollum and Galyean (1985) and Caton et al (1988) also noted a decrease in TMRT, whereas Hunter and Seibert (1980) reported a fall in forage DMD with proteins supplementation, which they attributed in a decrease in retention time.

Growth performance

The average daily gain increased (P=0.03) by CSM feeding. However, this was not affected by the level of supplement. The beneficial effect of CSM supplementation on liveweight change was most pronounced during the first three months of feeding (February–April) when the control steers lost 80 g per day, whereas those receiving 0.5 and 1.0 kg of CSM supplement gained 130 and 200 g/d, respectively. This confirmed earlier results of Lhoste et al (1975), Not (1975) and Rippstein (1980). As rains were three weeks earlier than expected there were rapid weight gains in all treatments during the final month of supplementation.

Residual effects of CSM during the rainy season

Forage intake and digestibility

Steers fed CSM during the dry season tended to consume more forage (P=0.07) than the control group (Table 2), while forage DMD was not affected. On metabolic body weight (MBW) basis, there was no difference in forage DDMI/kg MBW between the control and the supplemented groups. Similarly, the digestibility of forage DM and cell walls was not increased by previous protein deficiency. This is in contrast to Allden (1968) and Graham and Searle (1975) who found that sheep subjected to feed restriction eat more during the period of realimentation.

Table 2. *Residual effects of cottonseed meal supplementation on forage intake and utilisation by grazing steers during the rainy season.*

	CSM, kg/d			
	0	0.5	1.0	SE[1]
Forage DMI, kg	4.8[a]	5.2[b]	5,3[b]	0.16
DMD, %	69	69	67	1.7
DDMI, g/W.$^{0.75}$	58	56	60	2.6
Total CPI, g	307[a]	330[b]	340[b]	10.0
Digestible CPI, g	216	240	234	11.0
NDFI, kg/d	3.1[a]	3.4[b]	305[b]	0.11
NDFD, %	75	76	72	1.6
ADFI, kg	2.0[a]	2.2[b]	2.2[b]	0.07
ADFD, %	70	71	67	2.1
K_2, %/h	1.7[a]	2.4[b]	2.4[b]	0.25

TMRT, h	91.41	77[b]	76[b]	6.0
ADG, kg	0.26	0.43	0.39	0.03
ADG in 8 mo., kg		0.35	0 33	0 3

1 Standard error of least square means (n = 8)
ab Row means with different superscripts differ ($P<0.05$).

Forage digests passage kinetics during the rainy season

Steers fed CSM in the dry season had a faster rate of passage of the digests (P=0.02) and a shorter TMRT (P=0.05) compared with the control steers but level of CSM feeding had no effect.

Growth performance

At the end of supplementation period, there was a significant difference in body weight (P=0.001) between the supplemented and control steers. Since during the rest of the rainy season the growth rate of steers in all treatments was similar, the supplemented steers maintained their weight advantage (P=0.06), which is in agreement with studies by Hennessy and Williamson (1981) but in contrast to the results of many other workers in Africa (e.g. Butterworth 1985).

Simulation study

The model indicated that during the dry season the energy from forage seemed adequate, while protein was deficient to maintain body weight of grazing steers. Consequently, protein supplementation was required to prevent loss of body weight. Furthermore, the model also indicated that cattle would respond to modest amounts of urea (50 to 60 g of urea daily) whenever the forage CP content was below 10%. The use of the net energy (NE) system tended to overestimate gains, while the model using metabolisable protein (MP) system underestimated gains. Using inputs such as forage intake and digestibility, cattle weight and the distance walked and time spent grazing, this model can be used to rapidly estimate the energy and protein requirements for maintenance, the periods during which to provide feed supplements, and to predict the performance of grazing cattle in sub-Saharan environments.

In conclusion, data from this study suggest that protein is a major limiting nutrient for growth and forage utilisation by grazing zebu cattle on Soudano-Sahelian pastures during the dry season. It seems that above 200 g of CP provided by 0.5 kg of CSM supplement, additional protein does not promote further growth of grazing steers. This tends to agree with Robinson and Stewart (1968) who stipulated that zebu cattle were efficient in using low protein diets because they evolved in environments with frequent limited protein supply in forages. When a daily supplement of 0.5 kg of CSM is fed, forage DMI increased by 16% without depressing DM and cell wall digestion, the digesta rate of passage is enhanced while weight gain increased. Higher amounts of CSM do not further increase weight gain with the type of cattle used in this study, probably because the energy content of forage seems to be limiting. Because pasture regrowth is usually fast when the rains return, protein supplementation can be discontinued after three weeks of regular rains have fallen or when cumulative rainfall has reached 100 mm.

References

Allden W.G. 1968. Undernutrition of the merino sheep and its sequelae. I. The growth and development of lambs following prolonged periods of nutritional stress. *Aust. J. Agric. Res.* 19:621–638.

AOAC (Association of Official Analytical Chemists), 1984. *Official Methods of Analysis.* 14th edition. AOAC, Washington, DC, USA.

Butterworth M.H. 1985. *Beef Cattle Nutrition and Tropical Pastures.* Longman. 500 pp.

Cochran W.G. and Cox M.G. *1957*. *Experimental Designs* (2nd ed). John Wiley and Sons, New York, USA.

DelCurto T., Cochran R.C., Corah L.R., Beharka A.A., Vanzart E.S. and Johnson D.E. 1990. Supplementation of dormant tallgrass-prairie forage. II. Performance and forage utilization characteristics in grazing beef cattle receiving supplements of different protein concentrations. *Journal of Animal Science* 68:532–542.

Goering H.K. and Van Soest. *P.J.*1970*. Forage Fiber Analyses (Apparatus, Reagents, Procedures, and Some Applications).* Agriculture Handbook *379.* USDA (United States Department of Agriculture), Agricultural Research Service, Washington, DC, USA.

Graham N. Mc. and Searle *T.W.*1975*.* Studies of wearer sheep during and after a period of weight stasis. I. Energy and nitrogen utilization. *Aust. J. Agric. Res.* 26:343–353*.*

Hennessy D. W., Williamson P.J., Lowe R.F. and Baigent D.R. 1981*.* The role of protein supplements in nutrition of young grazing cattle and their subsequent productivity. *J. Agric.* Sci. (Camb) 96:205–212*.*

Hunter R.A. and Siebert B.D. 1980*.* The utilization of spear grass *(Heteropogon contortus). IV.* The nature and flow of digesta in cattle fed on spear grass alone and with protein or nitrogen or sulfur.*Aust. J. Agric. Res. 31:107–147.*

Lhoste P. Pierson J. and Ginisty L. 1975*.* Essai d'engraissement de boeufs Zebus à partir des farines basses de riz du Nord Cameroon. *Rev. Elev. Méd. Vét. Pays Trop.* 28:217.

Minson D.J. 1971*.* The nutritive value of tropical pastures. *J. Aust. Inst. Agric. Sci.* 37:255–263.

Piot J. 1975*.* Complémentation alimentaires en élevage semi-extensif sur savanes soudano-guinéennes d'altitude au Cameroon. *Rev. Elev. Méd. Vét. Pays Trop*. 28:67–77.

Pond K.R., Ellis W.C. and Matis J.H. 1984*.* Development and application of compartment Tec. Rep. *84–2.* Texas A&M College Station, Texas, USA.

Rippstein G. 1980*.* Comparaisons de régimes alimentaires d'entretien de Zebus au pâturage en saison sèhe dans l'Adamaoua camerounais. *Rev. Méd. Vét. Pays Trop.* 33:417–426.

Robinson D.W. and Stewart G.A., 1968. Protein digestibility in sheep and cattle in north-western Australia. *Aust. J. Exper. Agric. Anim. Husb.* 8:419–424.

SAS. 1990. *User's Guide: Statistics.* SAS Inst., Inc., Cary, NC, USA.

Uden P., Colucci P.E. and Van Soest P.J. 1980. Investigation of chromium, cerium and cobalt as markers in digesta. Rate of passage studies. *J. Sci. Food Agric.* 31:625–632.

Williams C.H., David. DJ, and Iismaa O. 1962. The determination of chronic oxide in faeces samples by atomic absorption spectrophotometry. *J. Agric. Sci.* 59: 381–385.

Complémentation protéique chez des bovins au parcours daps la zone Semi-aride du Cameroon

Résumé

L'effet d'une complémentation de tourteau de coton sur (ingestion et la digestibilité de matière sèche du fourrage et sur le gain moyen quotidien (GMQ) de bouvillons é1evés sur pâturage naturel dans la zone semi-aride du Nord-Cameroun a été étudié pendant 120 jours de la saison sèche. L'effet résiduel de cette complémentation a été analysé pendant une autre période de 120 jours de la saison des pluies. Trente bouvillons, pesant en moyenne 229 kg et âgés de 2,6 années, ont été répartis de manière aléatoire dans des blocs complets de 3 traitements (0; 0,5 et 1 kg de tourteau/animal/j). Après avoir reçu individuellement du tourteau servi à la main au cours de la matinée, les animaux ont tous été conduits sur un pâturage dominé par l'espèce *Andopogon* pour y brouter librement. Chaque mois, deux bouvillons par traitement ont été placés daps des cages de digestion et ont reçu à volonté du fourrage coupé en petits morceaux de composition botanique analogue à celle du matériel végétal consommé au pâturage par les autres animaux.

La complémentation a augmenté le taux de protéines brutes absorbées, la vitesse de passage dans le rumen et le gain moyen quotidien (GMQ). La consommation de fourrage n' a augmenté que pour la ration de 0,5 kg de tourteau de coton. La digestibilité de la matière sèche du fourrage et des parois cellulaires (NDF et ADF)

était généralement plus faible avec one compléméntation de 1 kg de tourteau qu'avec 0,5 kg ou sans complément du tout. Au cours de la saison des pluies, le tourteau de coton n'avait pas d'effet sur la digestibilité des parois cellulaires (NDF et ADF) et de la matière sèche du fourrage, le taux de protéines brutes absorbées et le GMQ. Ces résultats indiquent qu'une complémentation de 0,5 kg de tourteau peut accroître (ingestion de matière sèche du fourrage, la vitesse de passage dans le rumen et le GMQ des bovins au cours de la saison sèche et que ce gain de poids peut se maintenir tout au long de la saison des pluies.

Ces données ainsi que les informations disponibles sur le sujet dans la bibliographie ont été incorporées dans un modèle de simulation pour évaluer les besoins en protéines nécessaires à fentretien des bouvillons et déterminer la période pendant laquelle l'apport de complétments pourrait être économiquement avantageuse. Cette simulation a montré que le niveau de protéines était insuffisant pour satisfaire les besoins d' entretien de bouvillons élevés sur pâturage pendant la saison sèche et une partie de la saison des pluies. Une complémentation protéique ou azotée était nécessaire pour empêcher les pertes de poids. Des quantités

modérées d'urée (50 A 60 g/j/bouvillon) pouvaient suffire lorsque la teneur en protéines brutes du fourrage ééait inférieure à 10%, ce qui est généralement le cas de juillet à avril.

On-Farm Feed Utilization and Feeding Systems

The effect of feeding agro-industrial by-products on weight gain and body condition of draft oxen in Swaziland

B.H. Ogwang[1] and B. Xaba[2]

[1]University of Swaziland, P.O. Luyengo, Swaziland
[2]Ministry of Agriculture, P.O, Box 4, Malkerns, Swaziland

Abstract

Despite the importance of draft animal power in Swaziland, very limited research work has been conducted to assess the effect of dry season supplementary feeding on the performance of draught oxen. In this study this effect was investigated using 60 oxen belonging to 15 small-scale farmers in the Middleveld of Swaziland. Twenty-eight oxen had access to crop residues and agro-industrial by-products as supplements, while 32 relying exclusively on veld grazing served as a control. Estimated body weights and body condition were recorded monthly from June to November, 1992. Supplemented oxen had consistently higher weight gains and a better body condition compared to the control animals. However, the feed formulation appeared to be too expensive and therefore unsuitable for draft oxen under the existing economic conditions. It is recommended that opportunities for cost reduction of supplementation should be investigated.

Introduction

In those parts of Africa where rainfall is both seasonal and subject to large variations between seasons, grazing cattle are frequently subjected to periods of undernutrition and are unable to maintain their condition and live weight. Van Niekerk (1974) reported that, in southern Africa, unsupplemented animals may lose up to 30% of their maximum summer body weights during the dry winter period. Ogwang (1987) found that similar losses occurred between May and September in the Middleveld of Swaziland. Concern has been expressed that this weight loss could interrupt land tillage activities because of an assumed diminution of traction power. It is a widely held view that supplementary feeding of work oxen during the dry season is indispensable if delays in land preparation during the wet season are to be avoided (Bartholomew et al 1993).

Draft animal power (DAP) is very important in Swaziland and some 55% of rural households are known to use DAP. Cattle, donkeys and mules provide smallholder farmers with vital power for ploughing, ridging, weeding and transport. This study was designed to assess the growth response of draft oxen to dry season supplementary feeding with readily available crop residues and agro-industrial by-products. The hypothesis was that if draft oxen are well-fed prior to the cropping season, they will be strong enough to start ploughing early resulting in higher crop yields on smallholder farms.

Materials and methods

The study was carried out in the Middleveld of Swaziland where DAP is an important source of traction for farm operations. Fifteen participating farmers were chosen from Ntondozi, Zombodze and Maliyaduma districts. Each farmer owned four oxen. Twenty-eight oxen were fed supplements while 32 were monitored as controls relying only on grazing. Initially, the farmers were trained how to feed their oxen. The farmers were supplied with feed each fortnight and they were to feed each ox a daily ration of 3.5 kg. The composition of the feed offered is presented in Table 1. Animal measurements were carried out from June to November 1992.

Table 1. *Composition of feed offered to the oxen.*

Ingredient	% in the ration	% DM	% CP	ME (MJ/kg DM)
Maize bran	41.2	90	10.0	13.8
Brewer's residue	29.2	91	21.0	11.7
Molasses	27.4	84	4.4	43.0
Common salt	1.0	–	–	–

Body weight was estimated using a commercial tape to measure heart girth. Such tapes rely on the high correlations between the circumference of the chest and body weight. The heart girth was taken as an imaginary line beginning from a point slightly behind the shoulder blade, dropping down over the fore ribs and under the body behind the elbow of the front legs, and hack up the other side of the animal to its starting point.

Body condition scores were determined based on a visual assessment of the prominence of the hip bones and the ribs. For hip bones, the following scale was used: 1 = prominent; 2 = slightly protruding, and 3 = round and smooth. For the ribs, a scale of 1 to 3 was also used as follows: 1 = very conspicuous, 2 = slightly visible, and 3 = not visible. By combining the two parameters, an ox in the poorest condition scored 2 while the top scoring animal would receive 6 points.

Results

Reports from several regions in southern Africa (Van Niekerk 1974) suggest that protein and energy are the major nutrients limiting the productivity of grazing livestock. Levels of these nutrients in natural pastures are influenced by soil characteristics, rainfall patterns as well as by plant species composition. Figure 1 shows that the protein content of sampled veld forage in the study areas ranged from 3.2% during the driest months of July and August, to 3.9% at the peak of the rains in November. These protein levels are usually considered too low to maintain weight in mature cattle.

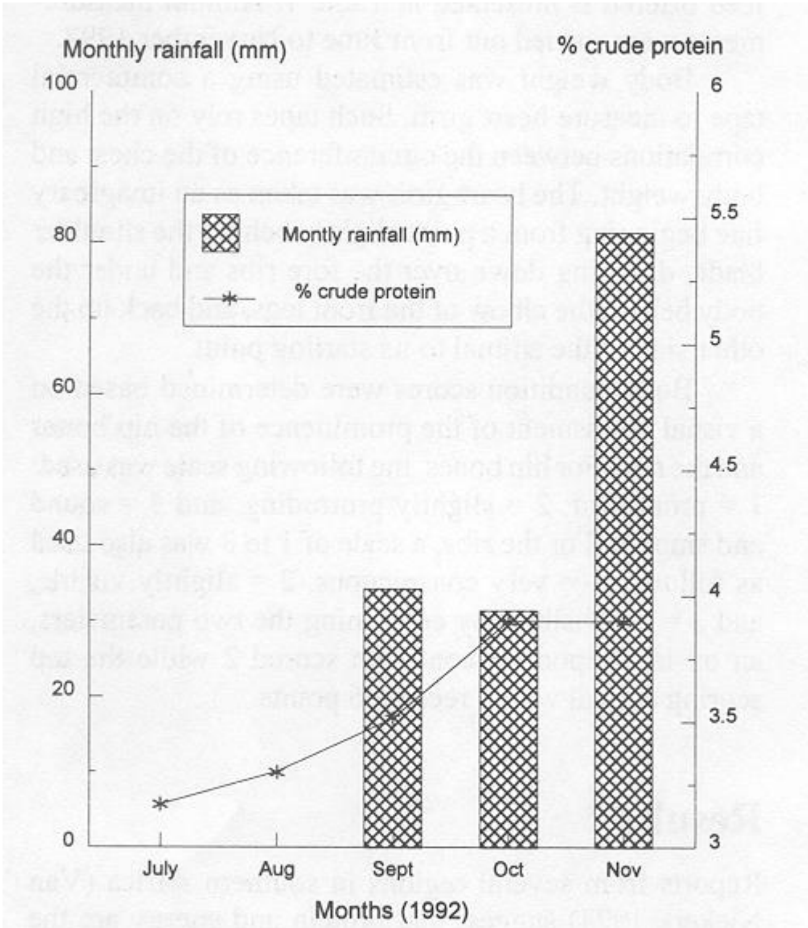

Figure 1. *Variations in rainfall and crude protein content of natural pastures in the Middle veld of Swaziland*

Analyses of body-weight changes were based on two age groups of oxen: relatively young (3–5 years) and old oxen (6–12 years). In general, the young oxen that received supplementation had higher weight gains compared to those that did not (Figure 2). Their positive response was rapid, following commencement of feeding in June. The control oxen also gained in weight after the onset of summer rains in September but at a slower rate. Weight changes in older oxen were less pronounced (Figure 3). These oxen were still losing weight in July, one month after the start of feeding, but in general supplemented animals gained faster than unsupplemented controls. Body conditions of both groups of oxen improved during the wet season (Figure 4). Supplemented animals were in slightly better shape than those that depended exclusively on grazing. The cost of feeding the supplements to four oxen per farmer from June to November amounted to 1,113 Emalangeni (370 US dollars) or 278 Emalangeni per ox.

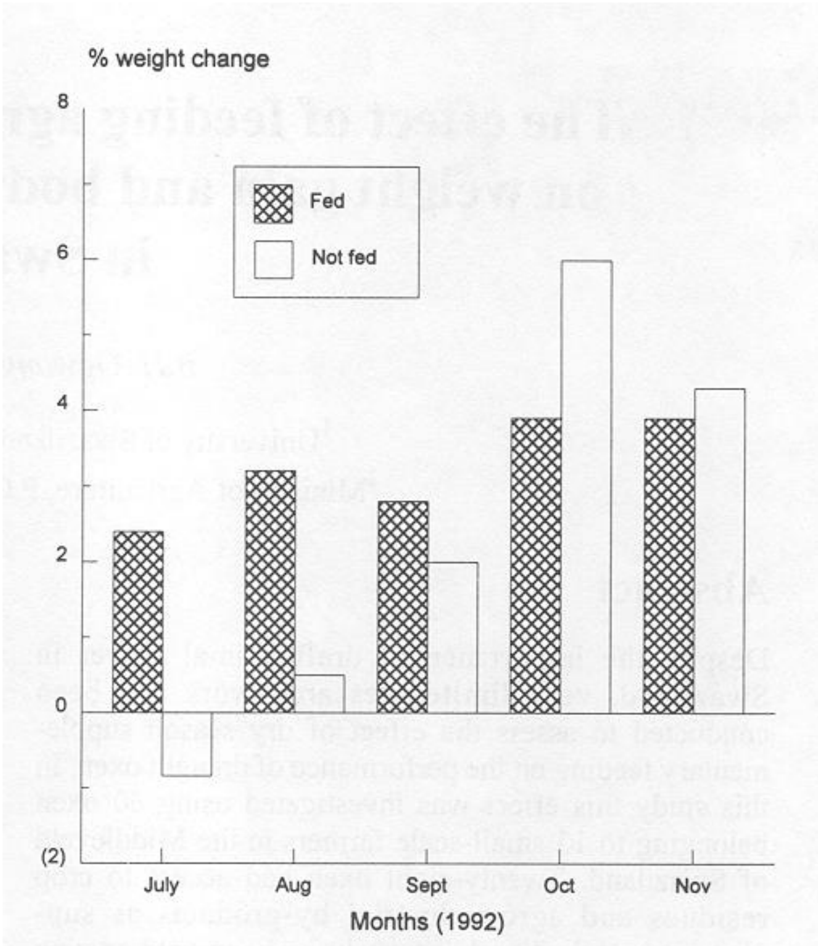

Figure 2. *Monthly changes in body weight of young oxen (age range 3–5 years, mean June weight 310±90 kg)*.

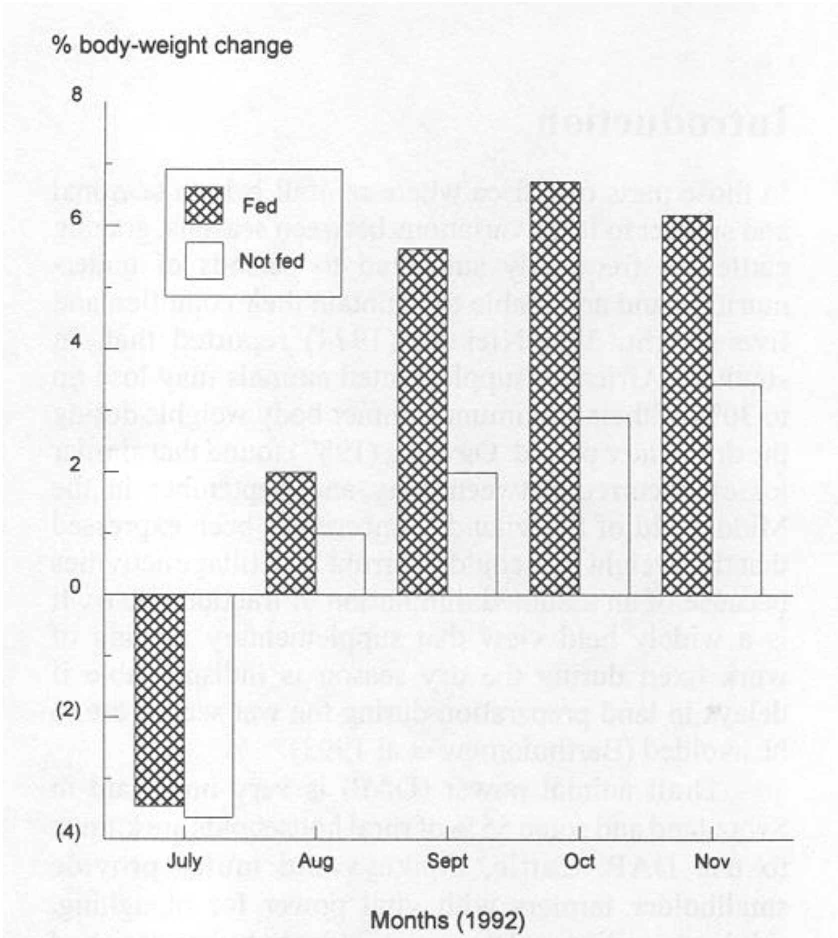

Figure 3. *Monthly changes in body weight of old oxen (age range 6–12 years, mean June weight 440±40 kg).*

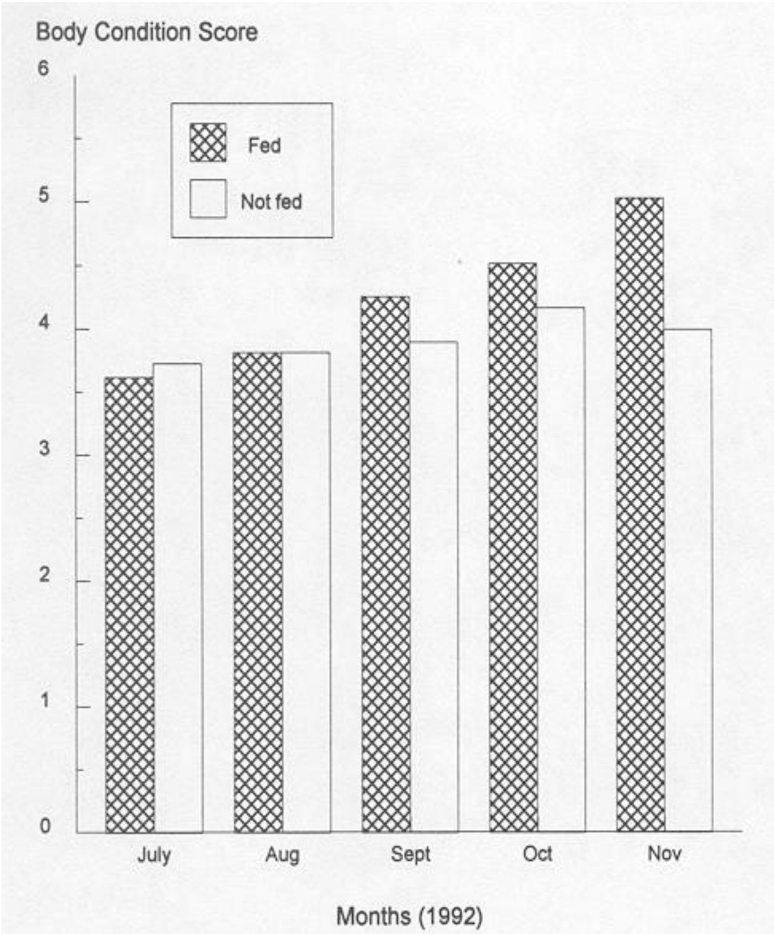

Figure 4. *Monthly changes in body conditions score of fed and control draft oxen.*

Discussion

Although there were wide variations in animal weights and condition scores as well as in farmer circumstances, this study provided some insight into the likely benefits of supplementary feeding of draft oxen. It indicated that strategic supplementation with agro-industrial by-products has a positive effect on liveweight and body condition. It may also increase growth rates of younger oxen.

It has often been reported that, to be appropriate to farmer circumstances, innovations require minimal additional investment (Fitzhugh et al 1992) partly because of the risks involved in crop production. Average maize yields on smallholder farms in Swaziland are probably about 1000 kg/ha/yr. A fifty per cent improvement in maize yield due to timeliness of ploughing with oxen could earn a gross return of about 800 Emalangeni. Compared with an investment of over 1,100 Emalangeni in feeds to supplement draft oxen, the feed package used in this study is unlikely to be acceptable to farmers. Therefore, there is a need to explore sources of cheaper supplements and establish the optimum level of supplementation required for the desired responses. Further cuts in cost could be accomplished through reduction of traction teams from the present four to two oxen by using better designed implements.

References

Bartholomew P.W., Khibe T., Little D.A. and Ba S. 1993. Effect of change in body weight and condition during the dry season on capacity for work of draft oxen. *Tropical Animal Health and Production* 25:50–58.

Fitzhugh H.A., Ehui S.K. and Lahlou-Kassi A.1992. Research strategies for development of animal agriculture. *World Animal Review* 72:3–14.

Ogwang B.H. 1987. Beef production from natural pastures at Luyengo University Farm. Research and Publications, University of Swaziland.

Van Niekerk B.D.H. 1974. Supplementation of grazing ruminants. In: *Proceedings of a Seminar on Potential to Increase Beef Production in Tropical America.* CIAT, Cali, Colombia.

Effet de la consommation de sous-produits agro-industriels sur le gain de poids et la condition corporelle de boeufs de trait au Swaziland

Résumé

Malgré l'importance de l'énergie de la traction animale au Swaziland, très peu de travaux ont été menés pour évaluer l'effet dune complémentation de saison sèche sur les performances des boeufs de trait. C'est le thème de la présente étude effectuée sur 60 boeufs appartenant à 15 petits exploitants agricoles du Middleveld au Swaziland. 28 de ces animaux recevaient des compliménts de résidus de culture et des sous-produits alimentaires, les 32 autres constituant le lot témoin, nourri exclusivement avec de l'herbe des pâturages naturels. Le poids vif des boeufs a été estimé et leur condition corporelle observée mensuellement de juin à novembre 1992. Les animaux recevant une complémentation ont enregistré une meilleure condition corporelle et des gains de poids plus élevés que ceux des boeufs témoins. Toutefois, compte tenu de leur composition, ces aliments étaient trop chers pour des boeufs de trait dans les conditions économiques actuelles. Il est recommandé d'étudier différentes possibilités d'en réduire le coût.

An economic evaluation of zero-grazing feeding system for high yielding cows on smallholder farms in Kenya

L.M. Mogaka

Kenya Agricultural Research Institute (KARI)
Regional Research Centre
P. O. Box 523, Kisii, Kenya

Abstract

A study was conducted on the economics of a cut-and-carry system using Napier grass to produce milk from high yielding dairy cows. An on-station test was conducted at RRC of Kisii (AEZ-UM 1) followed by 12 on-farm farmer-managed tests situated in Kisii (AEZ:UM1), Homa Bay (LM2), Nyamira (LH1) and Migori districts (LM 1). The objectives were to verify the viability of zero-grazing enterprises and produce data that financial institutions would use when considering credit applications by farmers. Data recorded included: feed intake, milk yield, labour requirements, fodder quality and other management practices of the system at monthly intervals. dry matter yield of about six tons/ ha/cut was realised in six cuts at intervals of eight weeks, with a mean crude protein content of 10.4%. Based on an average dry matter intake of 10 kg/cow/ day and left overs of 20%, the study suggested that one hectare of fodder Napier could sustain eight mature stock units (MSU = 400 kg live weight) with an average daily milk yield of 9.0 kg. The average farm-gate price of milk was set at US$ 0.13 per kg. Gross milk yield per lactation varied from 3030 (LM1) to 4414 kg (UM1).

With a supplement of 1 kg dairy meal per 1.5 kg milk/day/cow, daily milk yield ranged from 9 kg (LM1-2) to 14 kg (UM1, LH1). The average cost of feed supplement was US$ 0.07 per kg. Taking into account all cost components the rate of return ranged from US$ 2.6 (LM1-2) to US$ 3.0 (UM1, LH1). Labour was the major production cost (46%) followed by supplementary feeds (27.5%) and animal health (10.4%).

The average capital investment in a zero-grazing unit of 4 cubicles ranged from US$ 129 (LM1-2) to US$ 157 (UM1, LH1). This study showed that with a rate of return of 2.8 per annum, capital investment was recovered within two years when the value of follow ups and dung are excluded, suggesting that a zero-grazing enterprise has the potential for credit financing in AEZs under study.

Introduction

In high and medium potential areas of Kenya, dairy production is shifting from extensive grazing to more intensive (e.g. zero) systems due to diminishing farm sizes resulting from population growth and competition for land from food crops. This has led to less land remaining for livestock production (Jaetzold and Schmidt 1982). Therefore, developing more intensive systems of rearing dairy cattle becomes a necessity; zero-grazing maximises land use through the production of high yielding fodder crops and their efficient utilisation (Ibrahim 1988).

An informal farm survey was conducted in the mandate districts (Mogaka et al 1990) which indicated that zero grazing of dairy cows is not widely adopted because most smallholders are apprehensive about its high cost and likely non-profitability.

Farmers who have adopted the system use mainly improved breeds, such as Friesians, Guernseys, Ayrshires and their crosses. The adoption of zero-grazing is constrained mainly by lack of credit facilities, lack of initial capital, poor infrastructure, unavailability of pedigree breeds and the inefficient utilisation of fodders and on-farm by-products.

The study included an on-station trial followed by 12 farmer-managed tests on farms with two or more dairy cows under Napier grass based zero-grazing system of management. These tests aimed to determine the return on investment, to support applications by farmers to secure credit facilities and to assist the government to make input–output cost-price adjustments for smallholder dairy farmers. To evaluate this, input–output function analysis was used.

Napier (Bana) has been recommended as the main roughage because it is high yielding.

Materials and methods

Farms selected for the study are located in medium to high potential areas at altitudes of 1500–2300 m asl. Annual rainfall is reliable, bimodal, averaging 1000–2200 mm per annum. Mixed farming characterised the selected farms which had an average of 2 ha of arable land.

Farms keeping two or more dairy cows were randomly selected in collaboration with extension personnel. One on-station and twelve on-farm trials were spread across four agro-ecological zones (Table 1).

Table 1. *Agro-ecological zone (AEZ) and soil types of selected test farms.*

District	AEZ	Major soil types	No. of farms
Kisii	UM1	Nitosols, Phaeozems	5
Nyamira	LH1	Nitosols, Phaeozems	4
Migori	LM1	Phaeozems	2
Homa Bay	LM2	Phaeozems, Acrisols	2

Breeds used were Friesians, Ayrshires, Guernseys, Jerseys and their crosses. The animals were fed *ad libitum* with chopped Napier (2.5 cm size) as the main source of roughage. dry matter intake (DMI) based on amount offered and left over was recorded. On-farm by-products, especially sweet potato vines, maize stovers and banana stems and leaves, were fed during feed-scarce periods.

The total area of Napier was divided into six or more separate plots, assuming a cutting interval of 6–8 weeks; each plot was harvested at least once. Every time a Napier plot was cut, cutting date, colour of grass, cutting height and quantities of slurry and inorganic fertiliser applied were recorded by the farmers. The farmers were supplied with stationery and coloured indicator sticks. Applied slurry was quantified as all, most, half, little or none taken from the manure pit and mineral fertilisers were recorded in kg (Table 2). Slurry was collected in concrete pits and applied to Napier fields by making furrows between the Napier rows after weeding and covering them with soil. Adequate quantities of mineral fertilisers were rarely applied due to high cost. The farmers kept records on milk yield and supplementary feeds, and all input costs and sales (Table 2; Figures 1 and 2, respectively). The monitoring, data collected and sampling of fodder were done at monthly intervals. The DM content and nutritive value of fodder Napier was determined by proximate analysis. For the economic analysis, input–output function analysis was employed.

Table 2. *Means of recorded variables of forage production in 13 farms.*

Variable	Means
Area (ha)	0.4
DM yield (kg/ha/cut)	6200
Height (cm)	110
Cutting interval (wks)	8
MSU[1]	2.9
Inorganic fertiliser[2] (kg/yr)	71
Components of fed Napier grass	
DM leaves %	57
DM stem %	40
DM dead material %	3
%CP	10.4
%Ca	0.3
%P	0.2
DMI/cow/day (kg)[3]	10.4

1MSU = mature stock unit: 0.3 = calf; 0.7 = heifer.

2 NPK 20:10:10.

3 DMI = dry matter intake.

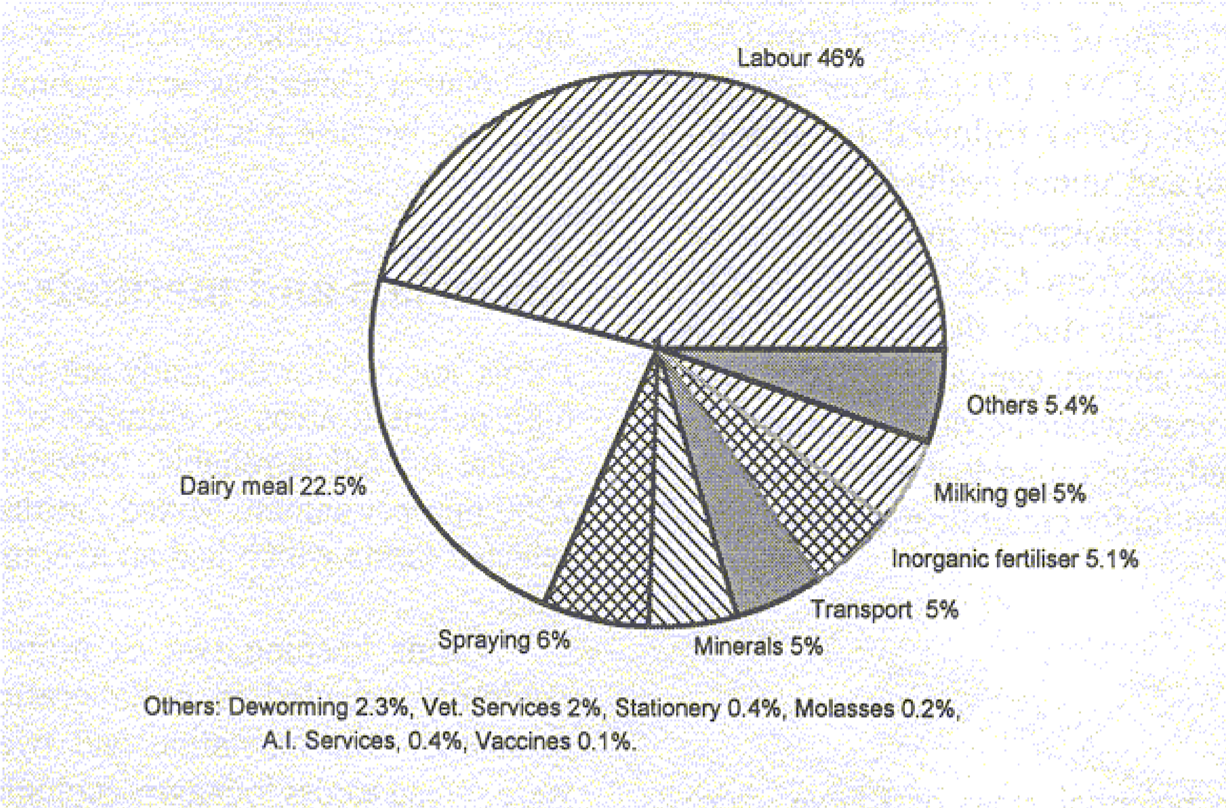

Figure 1. *Input components under small-scale zero-grazing condition.*

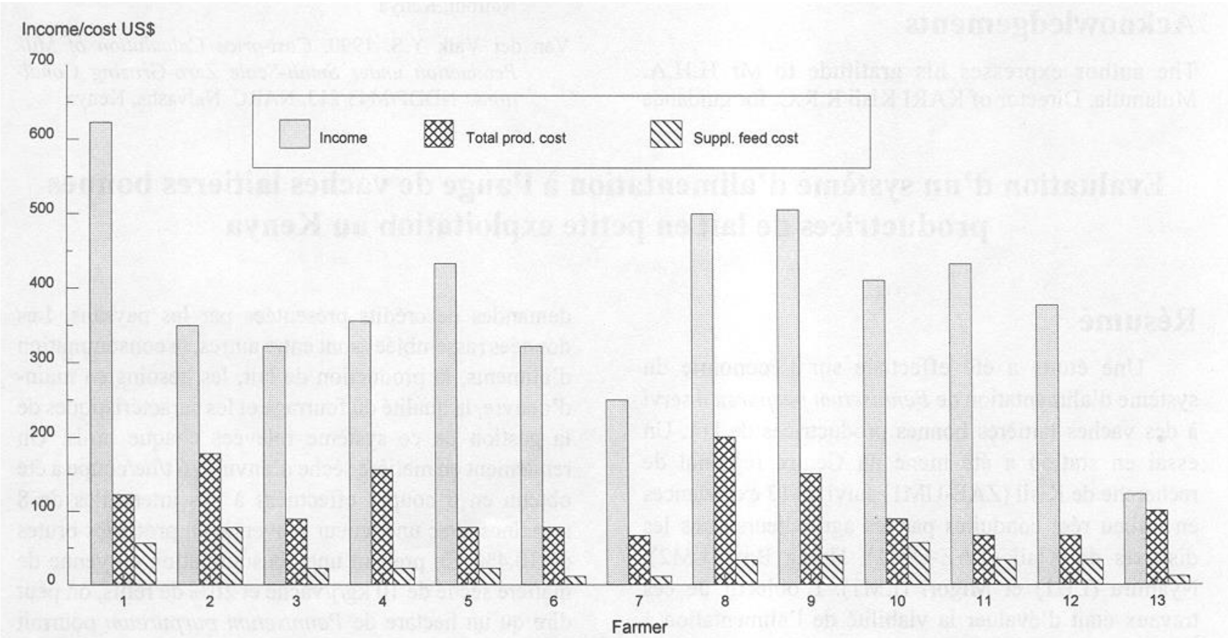

Figure 2. *Enterprise input–output levels/cow per year.*

Results and discussion

Napier management and utilisation indicate a cumulative DM yield of about 36 tons/ha/yr from six cuts (Table 2). The leaf stem ratio did not adversely affect forage intake as the stems were chopped to about 2.5 cm. The mean crude protein content of Napier cut at about a 1 m height was 10.4%. This is below the required 13% for maintenance and a milk yield of 10 kg/d (NRC 1978). This suggests that the protein gap from Napier needs to be bridged by supplements rich in proteins (concentrate or legumes) in order to fully exploit the milk production potential of dairy cows. Humphries (1991) showed that grass should at least contain 7% CP in order to prevent weight loss in cows and allow for production above maintenance. Minson (1990) reported that there is a rapid decline in voluntary intake when crude protein in feed falls below 7% DM.

Since about 36 tons DM yield/ha/yr in six cuts is possible (Table 2), 0.35 ha would yield 12.6 tons DM/ha/yr. Based on a DM intake (DMI) of about 10 kg/day/mature stock unit (MSU), this area could satisfy the DM requirement of 2.9 MSUs per year. Farmers with 0.35 ha were supplementing their feed supplies with on-farm by-products and roadside grass, while dairy meal was rarely fed due to high cost.

Average recorded daily milk yield was about 9.0 kg/cow (Table 3) and was sold at farm-gate price of US$ 0.13/1. Gross milk yield per day varied from 9 kg (AEZ:LMI-2) to 14 kg (AEZ:UM1, LH1). The average cost of dairy meal was US$ 0.07/kg. The study showed that the rate of return on the dollar ranged from US$ 2.6 (AEZ:LM1-2) to US$ 3.0 (AEZ:UM1, LH1). Labour was the major production cost (46%), followed by supplementary feeds (27.5%) and animal health (10.4%), respectively (Fig. l).

Table 3. *Average feed inputs and variables of milk yield.*

Parameters measured	Means[1]
Concentrate/lactation (kg)	492
Concentrate (kg/cow/day)	1.6
Milk from roughage (kg/cow/day)	7.2
Milk from concentrate (kg/cow/day)	2.4
Total milk yield (kg/cow/day)	9.6
Lactation length, days	308
Milk yield (kg/cow/lact.)	2958

Concentrate used = dairy meal.
1 Means of 13 cows in 3rd and 4th lactations.
One kg concentrate leads to extra milk production of 1.5 kg (Snyders 1992).

The study also indicated that in a cut-and-carry system, one adult man can adequately handle the equivalent of 1.3 MSUs. The average capital investment in a zero-grazing unit of four cubicles ranged from US$ 129 (AEZ:LM1-2) to US$ 157 (AEZ:UM1, LHI). Farmers can realise an average gross margin of US$ 248 and a net profit of US$ 125 per cow/year (Figure 2). Taking into account all costs the study showed that a farmer can produce a litre of milk at an average cost of US$ 0.046, varying from US$ 0.025 (AEZ:LH1) to US$ 0.069 (AEZ:UM1), (Figure 2). At a rate of return of 2.8/dollar/ annum, capital investment was recovered within two years (Table 4). Stotz (1983) calculated the average gross margin of zero grazing dairy cows (excluding heifers rearing) and arrived at a cost of US$ 0.036/1. Van der Valk, (1990) analysing cost price per litre of milk based on budget calculations and herd potential showed a cost of US$ 0.069 per litre.

Table 4. *Average economic performance of dairy cows.*

Variables	Means (US$)
Gross revenue	384.5
Total production cost/cow/year	136.1
Gross margin/cow/year	248.8
Total capital cost/cow/year	122.9
Net profit/cow/year	125.5

Cost/kg of milk; US$ 0.046: Sale price/kg of milk: US$ 0.130 (1 US Dollar = KSh 70; it should be noted that this exchange rate was exceptional and stabilised to 1 US$ = KSh 45 for most of 1994).

Conclusions

Napier grass vat Bana planted at a spacing of 90 × 60 cm and cut six times a year at a height of 1 m has a potential on-farm yield of about 36 tons DM/ha/year in the four AEZs in which trials were done.

Based on an average DMI of 10kg/cow/ day and DM wastage of 20% and stocking rate of 8 MSU/ha a milk yield of 7 kg/cow/day on roughage only can be attained.

Fodder Napier should be chopped to 2.5 cm diameter to reduce wastage and improve intake. The mean % CP content in fodder Napier in farmer's fields is 10.4% DM.

Supplementary feeding to overcome periodic falls in energy and .protein content in napier is essential to maximise milk production. Supplementation of dairy meal at the rate of 1 kg for every 1.5 kg of milk yield/day above 7 kg is recommended.

One adult man can provide sufficient labour of three MSUs. The zero-grazing system is a viable and economic proposition for smallholder dairy farmers.

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References

Humphries L.R. 1991. *Tropical Pastures Utilization.* Cambridge University Press.

Ibrahim K.M. 1988. Forage Plant Development and Extension in Kenya. AG; DP/KEN/84/007 Technical Report 34–36, Rome, Italy.

Jaetzold R. and Schmidt M. 1982. Farm Management Handbook of Kenya Vol. II — Natural conditions and Farm Management information part A. West Kenya. 94–99, 110–111, 142–150, 160–161.

Minson D.J. 1990. *Forage in Ruminant Nutrition.* Academic Press, Inc. pp. 9–58.

Mogaka L.M., Kiura J.N., Mbugua D.M. and Sunyai S.K., 1990. *On farm Survey Report on Economic Performance of Dairy Cattle. Annual Report 1990.* RRC-Kisii, Kenya.

National Research Council Standards. 1978. Nairobi, Kenya.

Snyders P.J.M. 1992. *Fodder Management and the Protein Gap on Zero-Grazing Farms Based on Napier Grass.* NAHRC, Naivasha, Kenya. 11 pp.

Stolz D. 1983. Production Techniques and Economics of Smallholder Livestock Production Systems in Kenya. Nairobi, Kenya.

Van der Valk Y.S. 1990. *Cost-price Calculation of Milk Production under Small-Scale Zero-Grazing Conditions.* NDDP/M43/213. NARC Naivasha, Kenya.

Evaluation d'un sysétme d'alimentation à l'auge de vaches laitières bonnes productrices de lait en petite exploitation au Kenya

Résumé

Une étude a été effectuée sur l'économie du système d'alimentation de *Pennisetum purpureum* servi à des vaches laitières bonnes productrices de lait. Un essai en station a été mené au Centre régional de recherche de Kisii (ZAE-UM1l) suivi de 12 expériences en milieu réel conduites par les agriculteurs dans les districts de Kisii (ZAE-UM1), Homa Bay (LM2), Nyamira (LH1) et Migori (LM1). L'objectif de ces travaux était d'évaluer la viabilité de l'alimentation à l'auge et d'obtenir des données dont les institutions financières pourraient se servir pour examiner les demandes de crédits présentées par les paysans. Les données rassemblées sont entre autres, la consommation d'aliments, la production de lait, les besoins en maind'oeuvre, la qualité du fourrage et les caractdristiques de la gestion de ce système relevées chaque mois. Un rendement en matière sèche d'environ 6 t/ha/coupe a été obtenu en 6 coupes effectuées à des intervalles de 8 semaines avec une teneur moyenne en protéines brutes de 10,4%. En prenant une consommation moyenne de matière sèche de 10 kg/j/vache et 20% de refus, on peut dire qu'un hectare de *Pennisetum purpureum* pourrait nourrir 8 unités de bétail adulte (une unité de bétail adulte = 400 kg de poids vif) avec une production moyenne de 9 kg de lait par jour. Le prix moyen du kilo de lait à la ferme à été fixé à 0,13 dollars E.U. La production totale de lait par lactation variait de 3030 (LM1) à 4414 kg (UM1).

Avec une complémentation d'un kilo de concentré laitier pour 1,5 kg de lait/j/vache, la production journalière de lait allait de 9 kg (LM1-2) à 14 kg (UM1, LH1). Le coût moyen de ce complément était de 0,07 dollars E.U. par kilo. Si l'on tient compte de toutes les composantes du coût, on obtient un taux de rendement allant de 2,6 (LM 1-2) à 3 dollars E.U. (UM1, LH1). La main-d'oeuvre constituait la principale composante du coût de production (46%), suivie des aliments complémentaires (27,5%) et des soins de santé animale (10,4%).

L'investissement en capital moyen d'une unité d'alimentation à l'auge de 4 boxes varie de 129 dollars E.U. (LM1-2) à 157 dollars E.U. (UM1, LH1). Cette étude montre qu'avec un taux de rendement annuel de 2,8, on peut récupérer cet investissement en 2 ans lorsque l'on ne tient pas compte de la valeur des activités de suivi et de celle des houses de vache. Cela signifie qu'une unité d'alimentation à l'auge de vaches laitières peut valablement béndficier d'un crédit de financement dans les zones agro-écologiques étudiées.

Factors limiting the use of fodders by smallholder dairy farmers in Kenya: Experiences from on-farm, farmer-managed, animal feeding trials

J.L Wandera, E.M. Kiruiro, V. C. Chemitei and B. O. Bulimu

National Agricultural Research Centre, P.O. Box 450, Kitale, Kenya

Abstract

On-station research in Kenya has developed several fodder sources that show potential for increasing milk yield from dairy cattle. Two farmer-managed on-farm trials were conducted that identified the technical problems associated with the use of some of these fodders; potential solutions were considered through discussions with selected farmers. In farms near Moi's Bridge site, there were no differences (P>0.05) in dry season milk production (1.7 2.4 kg/d) of cows crossbred (local zebu exotic breeds) fed on Napier fodder alone, Napier fodder plus 2 kg of dairy meal and those grazing natural pasture. In farms at the Kwanza site, Friesian cows fed cut-and-carry Napier fodder, *Desmodium* and sweet potato vines produced less (P<0.05) milk (5.31/d) than cows fed Napier fodder supplemented with dairy meal (6.5 kg/d) or cows grazing pastures with a supplement of Napier in the barn (6.0 kg/d). High labour requirements, hairiness of Napier grass and rapid decline in soil fertility of grass plots were major constraints limiting production and use of fodders on smallholder farms. The implications of the results of this on-farm research and farmers' responses are discussed.

Introduction

Milk yields on smallholder farms in Kenya are low, averaging 1900 kg per lactation or five litres per cow per day (Stotz 1983). A survey in 1991 in the districts of West Pokot, Uasin Gishu, Trans Nzoia and Keiyo Marakwet to diagnose the major causes of low milk production, identified the inadequate quantity and quality of available feeds as a major constraint.

Research has developed several fodders that produce adequate quantities of good quality herbage. Smallholder farmers were expected to grow and feed these fodders to their livestock. Why smallholder farmers do not grow and use these recommended fodders has not been adequately studied. The primary objective of this project was to find out whether improved fodders would increase milk production of dairy cattle in smallholder farms. We also sought to get feedback from farmers on the technical problems that limit production and use of these fodders.

Materials and methods

The study was farmer-managed and the farmers provided land, labour, experimental animals and routine management. They also collected milk production data. Researchers provided farm inputs and guidance on feeding and the collection of milk data. The trials were conducted with farmers near Chepalus Moi's Bridge in Uasin Gishu District and near the Kwanza Centre in Trans-Nzoia District.

The improved fodders evaluated were: Bana Napier *(P. purpureum),* Desmodium *(Desmodium uncinatum)* and a sweet potato *(Ipomea batatas)* variety known as Musinyamu. Dairy meal was evaluated as a supplement. The fodders were planted on 25 × 40 m plots, using conventional methods.

Six months growth of fodders were evaluated in a feeding trial. At the Moi's Bridge site, the feed treatments evaluated were: 1) the farmers' usual feeding system (grazing natural pastures consisting of mainly *Digitaria scalarum* and *Cynodon dactylon);* 2) stall-feeding 50 kg of fresh Bana Napier, and 3) stall-feeding 48 kg of fresh Bana Napier plus 2 kg of dairy meal. At the Kwanza site, the treatments were: 1) farmers' usual system (grazing a pasture of *Chloris gayana* – *Digitaria scalarum* plus stall-feeding of Napier in the evening and during milking); 2) stall-feeding 40 kg bana Napier plus 5 kg *Desmodium* plus 5 kg potato vines, and 3) stall-feeding 50 kg Bana Napier plus 4 kg dairy meal.

The three feed treatments were evaluated using a Latin square design with three lactating cows as columns and three feeding systems/periods as rows. The feeding period lasted 14 days at Moi's Bridge in the dry season and 9 days at the Kwanza site in the rainy season. Each feeding system was separated by an adjustment period of seven days. The cows used in the trials were crosses between local zebus and exotic breeds at the Moi's Bridge site and pure Friesians at the Kwanza site.

We estimated the total milk produced during the feeding period for each treatment and identified the technical problems associated with production and use of fodders through discussions with the two participating farmers and with extension personnel from Trans Nzoia and Uasin Gishu districts.

Results

Although supplementing Napier grass with dairy meal increased milk production by over 0.5 kg/d litres (42%) at Moi's Bridge site, the increase was not significant (Table 1).

Table 1. *Dairy milk yield (kg/d) during a 14-day period in the dry season at Moi 's Bridge site for three feeding systems.*

Feeding System	kg/d
Grazed natural pastures	1.9
Stall-fed Bana grass alone	1.7
Stall-fed Bana grass + 2 kg dairy meal	2.4

Supplementing grazing with stall-fed Bana grass or adding dairy meal to stall-fed grass produced more milk than an all stall-fed forage mixture that included a legume and sweet potato vines. Adding 4 kg of dairy meal raised daily milk yield by 23 per cent (Table 2).

Table 2. *Daily milk yield (kg/d) for three feeding systems at Kwanza site during a 9-day period in the rainy season.*

Feeding system	1/d

Grazing pasture + stall-fed Bana grass	6.0[a]
Stall-fed Bana grass + *Desmodium*+ sweet potato vines	5.3[b]
Staff-fed Bana grass + dairy meal	6.5[a]

ab Values followed by a similar letter were not significant at *P<0.05.*

Farmers and extension personnel experienced three general problems when production growing and feeding fodders:1) Weeding, cutting, carrying and feeding were found to be labour-intensive and cumbersome; 2) the hairiness of the Bana grass made handling difficult; 3) the soil fertility of Bana plots declined rapidly with continued grass harvesting.

Discussion

The response in milk production to dairy meal supplementation was expected as it provided a ration balanced for energy and protein. Grazing gives animals an opportunity to select high quality forage and therefore grazing cows produced slightly more milk than those on stall-fed grass alone (Table 1). That grazing was better than stall-feeding with grass and *Desmodium* and potato vines (Table 2) was unexpected as the fed mixture is high in crude protein. However, some studies suggest that *Desmodium* has lower *in vitro* organic matter digestibility than Bana grass (Snyders et al 1992; Kiura 1992; Jones 1969). The two farmers discovered the bene of dairy meal early in the trial, and they secretly fed dairy meal to the cows that were not on the dairy meal treatment. Other explanations for the unexpected results are: (1) the cows on trial had never been stall-fed before; the unusual environment and feeds reduced their feed intake and consequently their milk production and (2) the small 3×3 Latin square design provided insufficient degrees of freedom to test treatment effects.

In conclusion, the results of this study show that: farmer-managed on-farm animal research trials require close supervision to reduce sources of experimental error; the use of desmodium and potato vines as supplements to Bana grass did not improve milk production; feeding Bana grass supplemented with dairy meal increases milk production; farmers readily adopt technologies that are proven viable but production and use of alternative fodders still pose technical problems requiring further research.

References

Jones R.J. 1969. A note on the *in vitro* digestibility of two tropical legumes *Phaseolus atropurpureus* and *Desmodium intortum. J. Aust. Inst. of Agric. Sci.* 62–63.

Kiura J. D. 1992. *Evaluation of Protein Digestibility of Napier Grass (P.* purpureum) *and Green Leaf* Desmodium (D. intortum). MS thesis, University of Wageningen, Netherlands.

Snyders P.J.M., Nahuis A., Wekesa F. and Wouters A.P.1992. *Yield and Quality of a Mixture of Napier Grass and Green Leaf Desmodium at Two Cutting Regimes.* Kenya Agricultural Research Institute (KARI), National Animal Husbandry Research Centre, Naivasha, Kenya. 38 pp.

Stotz D. 1983. *Production Techniques and Economics of SmallHolder Livestock Production Systems in Kenya.* Farm Management Handbook of Kenya, Volume N. Ministry of Livestock Development, Animal Production Division, Nairobi, Kenya. 140 pp.

Facteurs limitant l'utilisation du fourrage dans les petites exploitations laitieres au Kenya: résultats d'essais d'alimentation animale conduits en milieu réel par les paysans

Résumé

Au Kenya, la recherche en station a permis de développer plusieurs sources de fourrages susceptibles d'accroître la production de lait de vaches. Deux essais en milieu réel conduits par les paysans eux-mêmes ont été effectués pour cerner les problèmes techniques liés à l'utilisation de certains de ces fourrages. Des solutions possibles ont été examinées au cours des discussions avec certains de ces paysans. Un essai effectué dans des fermes situées à proximité de Moi's Bridge n'a permis de mettre en évidence aucune differénce significative (P>0,05) dans la production laitière de saison sèche (1,7 à 2,4 1/j) entre les vaches croisées (zébu local × race exotique) recevant du fourrage de *Pennisetum purpureum* seul ou complémenté avec 2 kg de concentré laitier et celles é1évdes sur pâturage naturel. Sur les fermes du site de Kwanza, la production de lait (5,3 1/j) de vaches de race Frisonne nourries avec du fourrage de *P. purpureum*, de *Desmodium* et de fanes de patate douce servis à l'auge était supérieure (P<0,05) à celle des animaux recevant du fourrage de *P. purpureum* complémenté avec des concentrés (6,5 I/j) ou élevés sur pâturage naturel et recevant un complément d'herbe à eléphant servi à l'auge (6 kg/j). Les besoins élevés en main-d'oeuvre, la villosité de *P. purpureum* et la dégradation rapide de la fertilité des sols des parcelles de graminées constituaient les principales contraintes limitant la production et l'utilisation de fourrages dans les petites exploitations. Les implications des résultats de ces essais en milieu paysan et les réactions des paysans ont été analysées.

The evaluation of different protein and energy supplements on milk production in pasture-grazed Friesian cattle

E.M. Kiruiro and V.C. Chemitei

National Agricultural Research Centre, P. O. Box 450, Kitale, Kenya

Abstract

A conventional dairy cattle ration (A) and two locally blended energy-protein supplements (B and C) were compared using Friesian cattle grazing Rhodes grass *(Chloris gayana)* pastures during the dry season from October 1991 to January 1992 at the National Agricultural Research Centre, Kitale. The two locally blended supplements contained 160–180 g CP/kgDM and consisted of mixtures of maize bran, ground maize-on-the-cob, shredded local fish ("omena") and either sunflower seedcake or ground sunflower seeds (with husks); these were offered at a rate of 4 kg/hd/d as feed.

Pasture was grazed by nine Friesian cattle rotated between two paddocks totalling 2.5 ha for 84 days in a 3 × 3 Latin square design replicated thrice. Milk yield and its butterfat (BF) content, and chemical composition of the feed supplements and pasture, were determined. The daily milk yields between treatments A, B and C were 9.9, 10.6 and 10.7 kg/hd ($P<0.005$); the corresponding BF contents were 4.1, 3.9 and 4.0%, respectively ($P<0.005$). The results demonstrated the potential of locally blended concentrates in improving milk production during the dry season. These supplements were cost-effective in the area of the study and can therefore be recommended to smallholder dairy farmers who use improved pastures as the main roughage feed to produce milk from Friesian cows.

Introduction

Ruminant livestock in Kenya continue to rely mainly on natural pastures as their source of feed. However, it is recognised that milk production remains low unless animals grazing these forages are supplemented particularly during dry seasons when herbage quality deteriorates. Commercial dairy meal, as a supplement will no longer be affordable by most farmers due to escalating costs and unavailability. The approach to explore the use of locally available ingredients to formulate substitutes to daily meal therefore becomes necessary.

The objectives of the present study was to compare commercial daily meal with on-farm produced supplements on their effect on milk production and composition by Friesian cattle grazing Rhodes grass pasture during the dry season and to further assess the economics of supplementation.

Materials and methods

Animals and management

Nine cows were selected from the general herd based on milk production, lactation number and stage of lactation. The nine cows within 2–4 months of calving from each other, had an average milk yield of 8.2 kg per day over a two-week pre-experimental period. The cows were divided into three treatment groups to which the three experimental concentrate supplements were randomly assigned. Animals were fed the experimental diets for two weeks before the start of the experiment. Individual milk yields for each cow were recorded daily and aliquot samples taken during the last two days of each period for the analysis of milk fat.

Animals were drenched against internal parasites before the start of the experiment and dipped weekly against external parasites.

Diets and feeding

The basal diet consisted of herbage from a Rhodes grass *(Chloris gayana)* pasture established in 1985. The pasture was mowed in June 1991 after which it was top-dressed with urea (46% N) a month later. Animals grazed rotationally on the 2.5 ha pastures split into two paddocks. Fresh water was available at all times inside the paddocks.

The physical composition (kg/tonne) of the supplements was as follows:

Supplement A:	Daily meal	980
	Mineral mix	20
Supplement B:	Maize-on-cob meal	400
	Sunflower seed Cake	250
	Wheat bran	280
	Shredded fish	50
	Mineral mix	20
Supplement C:	Maize-on-cob meal	400
	Ground sunflower Seeds	200
	Maize bran	280
	Shredded fish	100
	Mineral mix	20

All the ingredients with the exception of daily meal were mixed on a clean or polythene-lined concrete floor using shovels with constant turning to ensure uniform mixing. A mineral mixture comprising of a commercial mineral formula (Baymix maziwa; Wellcome (K) Ltd) fortified with limestone ($CaC0_3$) in the ratio 9:1, was added during the mixing. The limestone was excavated locally. Mixture of B and C was prepared in 100 kg batches sufficient to last four to six days to avoid any possible moulding or rancidity due to oil-rich fish in the mixtures.

During the experiment, each diet was offered over three 28 days period (1, 2 and 3) each comprising 14 days of adaptation and 14 days data collection. The supplements were offered in two equal portions during the morning and evening milking at a daily rate of 4 kg per head. Samples of the concentrates and pasture were taken twice in each period, dried at 60°C for 72 h, for dry matter (DM) determination, ground through a 1-mm sieve before bulking for subsequent chemical analyses.

Statistical analysis

Data on milk yield and composition was subjected to standard analyses of variance with means compared for statistical differences using the Least Squares Means (LSM) method.

Results

The experiment lasted for 84 days split into three 28-day periods (Periods 1, 2 and 3) during which pasture was sampled for chemical analyses. The mean contents of crude protein, neutral detergent fibre, and minerals (Ca, Mg, P and Na) of the supplements and pasture herbage are shown in Table 1.

Table 1. *The mean chemical composition* of *grazed herbage and supplements offered to cattle (g/kg)*[1]

	Component						
	DM	CP	NDF	Ca	P	Mg	Na
Herbage							
Period 1	539	184	71.4	2.4	2.3	–	0.31
Period 2	567	121	71.0	3.8	1.6	–	0.30
Period 3	637	89	77.0	3.2	4.9	–	0.24
Supplement							
A	893	119	–	0.76	6.0	0.20	2.2
B	907	163	–	0.74	8.5	0.32	4.2
C	853	271	–	1.5	9.4	0.42	6.2

1 Based on two samplings each for both supplements and pasture per period.

The results indicate that the NDF content of the herbage increased while CP level declined with advancing maturity of the pasture (Periods 1 to 3). There were no discernible trends in the mineral contents in the pasture herbage whereas locally made supplements had generally higher mineral levels than the commercial daily meal.

Animals in all treatments were generally in good body condition except for one animal which developed lumpy skin disease and was removed from the experiment. A missing data procedure was employed in the statistical analyses.

Although liveweight measurements were not taken, it was observed that animals at the end of the experiment were generally in better body condition than they started particularly those on fishmeal-based supplements.

The effect of supplementation with the three concentrate formulations on milk yield and butterfat BF is presented in Table 2.

Table 2. *The mean daily milk yield (kg/hd) and butterfat content (%) for pasture-grazing cattle offered different supplements.*

Treatment	Daily milk yield (kg/hd)	Butterfat (%)

Supplement A	9.9	4.1
Supplement B	10.6	3.9
Supplement C	10.7	4.0
SE	0.29	0.21

There were no significant differences in milk yield between supplements A and B or between B and C (P>0.05), but supplements C gave significantly higher (P<0.05) milk yield than A. Differences were not significant (P>0.05).

Discussion

Pasture nutritive value and milk yield

Lactating dairy cattle in Kenya continue to rely on natural pastures whose quality and quantity seasonally varies with rainfall availability. During the dry season crude protein levels in the pasture may fall below the 60 g/kgDM required for grazing animals to meet their maintenance requirements (Minson and Milford 1967) due to reduced feed intake and digestibility (Minson 1982). Lower digestibility results in a decline in available energy, protein (Butterworth 1967) and minerals (McDowell 1985).

Table 3. *Chemical composition (g/kg DM) and unit cost of ingredients used in formulating the supplements.*

	Composition (g/kg)		
Ingredient	DM	CP	Unit cost[1]
Maize-on-cob meal	900	82	2.50
Maize germ	918	125	1.30
Wheat bran	850	162	2.90
Sunflower seeds	920	165	7.00
Shredded fish	nd	388	15.00
Dairy meal	930	134	4.65

1=Based on prevailing retail prices at Kitale (Oct. 1991) and excludes transportation costs.
nd =not determined.

Except for period 1, crude protein (CP) content of pastures (Table 1) were below that recommended for the level of milk production observed (ARC 1980).

The additional nutrients in the three supplements may have stimulated greater forage intake and more efficient rumen fermentation producing the milk levels recorded. It is noted that CP and minerals content in the commercial dairy meal (A) were lower than in the other diets (Table 1) and may partly explain the lower, milk yield.

Small amounts of fishmeal have been shown to significantly increase animal performance, this being attributed to its low nitrogen solubility and a shorter retention time in the rumen; this increases the flow of ammino acids absorbed post-ruminally (Preston and Leng 1987). Its inclusion in the current study was aimed at exploiting this phenomenon. Apart from the high protein levels, it is possible that the synergestic effect of by-pass nutrients from fishmeal could have caused a more efficient use of absorbed nutrients resulting in a higher milk production in fishmeal-containing diets; this being significant for supplement C with the highest level of fishmeal (100 g/kg) over supplement A (Table 2).

Broster et al (1969) showed that feeding a high plane of nutrition in early lactation led to considerable residual effect later in the lactation thus improving total lactation yield.

This is important in view of the low plane of nutrition dairy cattle in the tropics, including Kenya are often exposed to during the long dry periods which culminates in low milk production and poor body conditions. Supplementation during such critical periods is not only beneficial in maintaining high milk production levels but it could also improve the animals reproductive performance.

Economics of supplementary feeding

The economics of feeding the supplements to grazing cattle will depend on the prevailing prices of the ingredients and milk. Data in Table 4 have been drawn to demonstrate the cost:benefit ratios under different price structures for each supplement during the 84-day period. It can be observed that it was economic to supplement pastures with the tree supplements (A, B and C); return per shilling spent on levels (Table 2) and the unit cost of the supplements (see Table 3), it would appear that supplement B would be the most cost-effective since it has a favourably lower cost than the others and mean milk yield is not significantly lower than that obtained from supplement C.

Table 4. *Total milk yield and economic analysis data.*

	Milk			Total milk		Cost/benefit ratio[2]
Cow no.	Suppl. A	Suppl. B	Suppl. C	Yield (kg)	Revenue (KSh)[1]	
GF87	295.7	367.4	405.6	1068.7	4272.80	3.9
GF68	239.2	236.6	135.2	611.0	2444.00	2.2
GF27	289.4	324.6	352.0	1066	4264.00	3.9
GF118	253.1	219.5	274.1	746.7	2986.80	2.7
M154	151.1	154.9	200.4	506.4	–	–
GF44	–	226.7	226.3	453	nd	nd
M156	283.2	296.7	256.0	835.9	3343.60	3.1
K59	281.4	296.4	215.3	793.1	3172.40	2.9
436	2009	337.2	304.2	842.3	3369.20	3.1

1 For yield recorded over the 84-day period.

2 Unit costs of supplements A, B and C are KSh, 5.10, 3.80 and 4.10, respectively, based on unit prices shown in Table 3.

nd: not determined due to missing value for treatment A.

It must be emphasised that the recorded increase on production is that obtained over a lactation period of 12 weeks during a dry period. However, a consideration of the economics of supplementation should at farm level critically assess the cost of mixing, transportation, and other management costs on animals and pastures.

It would, however, appear from the outset that feeding of locally formulated supplements (B and C) was economic at farm level at least within the prevailing prices and within the Kitale environs. Further, the cost of supplementation may be reduced if the farmer produces and/or processes on the farm some of these ingredients such as maize-on-cob meal and sunflower seeds. These supplements are therefore recommended as replacements to the commercial daily meal.

Conclusions

The results from this study have shown that supplementing pasture grazed cattle during the dry season maintained high milk yield. Additionally, diets formulated from local protein and energy ingredients were cost-effective within the prevailing costs and have potential for use as replacement to the conventional dairy meal in maintaining a high milk production in the dry season. These supplements are therefore recommended for grazing practices at least within the Kitale town environs. A strategic feeding of high milk yielders is, however, recommended to make the system even more economically viable. Their use under zero-grazing Napier-based feeding system should also be investigated.

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References

ARC (Agricultural Research Council). 1980. Commonwealth Agricultural Bureaux, Slough, London.

Broster W.H., Broster V.J. and Smith T. 1969. Experiments on the nutrition of the dairy heifer. 8: Effect on milk production of level of feeding at two stages of lactation. *Journal of Agricultural Science. (Camb).* 72:229–245.

Butterworth M.H. 1967. The digestibility of tropical grasses. *Nutr. Abstr. Rev.* 37:349–368.

McDowell L.R. 1985. Nutrient requirements of ruminants. In: McDowell L.R. (ed), *Nutrition of Grazing Ruminants in Warm Climates.* Academic Press, Inc. Harcout Brace Jovanivoch Publ.

Minson D.J. 1982. Effects of chemical and physical composition of herbage upon intake. In: Hacker J.B. (ed), *Nutritional Limits to Animal Production from Pastures.* Commonwealth Agricultural Bureaux, Slough. pp. 167–182.

Minson D.J. and Milford R. 1967. The voluntary intake and digestibility of diets containing different proportions of legume and mature pangola grass *(Digitaria decumbens). Aust. J Agric. Anim. Husb.*7:456–551.

Preston T.R. and Leng R.A. 1987. *Ruminant Production Systems. Matching Ruminant Production Systems with Available Resources in the Tropics and Sub-tropics.* Penambul Books, Armidale, Australia.

Effet de différents compléments protéiques et énergétiques sur la production laitière de vaches Frisonnes élevées sur pâturage

Résumé

Une ration classique pour vaches laitières (A) et deux rations complémentées avec un mélange protéino-énergétique préparées sur place (B et C) ont été comparées sur des vaches Frisonnes élevées sur pâturage de *Chloris gayana* pendant la saison sèche, d'octobre 1991 à janvier 1992, au Centre national de recherche agricole de Kitale. Ces deux compléments, qui contenaient 160 à 180 g de protéines brutes/kg de MS et étaient composés de son de maïs, d'épis de maïs broyés, de poisson local broyées ("omena") et soit de tourteau de tournesol, soit de graines de tournesol broyées (non décortiquées), étaient offerts à raison de 4 kg/j/animal.

L'essai a été conduit pendant 84 jours sur 9 vaches Frisonnes tournant sur deux parcelles d'une superficie totale de 2,5 ha, selon la méthode du carré latin (3 × 3) avec 3 répétitions. La production laitière et le taux de matière grasse (MG) du lait ainsi que la composition chimique des compléments alimentaires et du fourrage naturel ont été déterminés. La production laitière des animaux recevant les rations A, B et C était respectivement de 9,9 ; 10,6 et 10,7 kg/j/tête ($P<0,005$) et les taux correspondants de matière grasse de leur lait étaient de 4,1; 3,9 .et 4 % ($P<0,005$). Ces résultats montrent que les compléments pioduits sur place permettent d'améliorer la production de saison sèche. Ces concentrés étant rentables dans la zone d'étude, on peut les recommander aux petites exploitations qui produisent du lait à partir de vaches Frisonnes élevées sur des parcours améliorés constituent la principale source de fourrage des animaux.

Effect of stocking rate on the botanical composition and nutritive value of diets selected by West African Dwarf goats on farmer-managed stylo fodder banks in central Nigeria

R.M. Njwe[1], A. 0. Ikwuegbu[2], G. Tarawali[2] and D.A. Little[2]

[1]University of Dschang, B.P. 222, Dschang, Cameroon
[2]ILCA, PMB 2248, Kaduna, Nigeria

Abstract

Smallholder farmers in the subhumid zone of Nigeria keep small flocks of goats, which need to be tethered or otherwise confined during the growing season to avoid trespass and damage to crops. Being constrained for six months or more, reduces mobility and feed intake resulting in lower goat productivity. To solve this problem, some farmers established small stylo-enforced fallows on which they confined their goats during the cropping period. For these fallows to retain sufficient stylo over several years, appropriate stocking rates of goats need to be determined.

This paper reports on a on-farm stocking rate trial, involving four farmer-managed stylo-fallows of 0.10 to 0.16 in size, which were stocked at 24, 42, 52 and 81 goats per hectare over a 3-month period from August to November 1992. Pasture components (stylo, grasses, forbs) were determined on three dates by plot sampling. On the same dates, diet composition and its nutrient content were derived from extrusa of oesophageally fistulated goats. Data on the composition of pasture and diet allowed the calculation of a selectivity index for the three pasture components.

Average sward composition was 54% grasses, 32% stylo and 13% forbs. Overtime, forbs increased and grass declined from 60% in August to 45% in late October, while stylo content rose slightly across stocking rates. Stylo was preferred at all times, rising from 50% of the diet in early September to 80% in mid October but declined when leaf fall started. Throughout the period, the selectivity index of stylo was unity, averaging 2.44 across stocking rates and sampling dates.

Crude protein content in the diets declined with stocking rate from 14.8 to 12.8% and with time ($P<0.05$) from 16.2 to 12.8%. Degradability averaged 73%, and decreased ($P<0.05$) with increasing stocking rate but not with time. Given these results, the optimum stocking of 40 goats/ha (800 kg LW/ha) was recommended which would guarantee a high proportion of stylo in the fallow sward and in the diet.

Introduction

Smallholder farmers at Abet keep mainly goats as part of their crop-oriented production system. During the cropping season goats are tethered on small parcels of pasture or fallow in order to avoid crop damage; this tends to affect their productivity adversely. In response to this problem several farmers have sown *Stylosanthes hamata* in fallow to create small fodder banks that aim at improving crop yields through maintaining soil fertility and at the same time ensure adequate feeding of small ruminants during the cropping period (Ikwuegbu and Ofodile 1992). Under these on-farm conditions, stocking rates vary greatly and some fodder banks are overstocked implying that animals grazing them may not have sufficient feed during the wet season. Overstocking of fodder banks may have adverse effects on botanical composition and nutritive value of the selected diet. Understocking tends to encourage nitrophilous grasses thereby ousting the more nutritious legumes. The objective of the trial was therefore to assess the effect of stocking rate on the botanical composition of the sward and on the nutritive value of the diet selected by goats grazing farmer-managed fodder banks.

Materials and methods

Four fodder banks (A, B, C and D) — 0.12, 0.11, 0.16 and 0.10 ha in size — were grazed during three months (August through to early November) at average stocking rates of 24, 42, 52 and 81 adult goats/ha, corresponding to 480 to 1620 kg liveweight or 1.9 to 6.5 TLU per ha; across the grazing period rates varied somewhat, as farmers removed or added animals to their flocks.

During September and October, diet composition of grazing goats was sampled by three oesophageally fistulated animals at two-weekly intervals. Prior to sampling, they were fasted for 16 hours (i.e. as from 5 pm). The fistulated goats were allowed to graze for 30 minutes on each fodder bank. After the bag was detached and emptied, the extrusa sample from each animal was weighed, transferred into a clean muslin cloth, gently squeezed to remove excess saliva (where necessary), and then mixed thoroughly with a spatula. A subsample of about 5 g was removed for estimation of proportions of stylo, grass and forbs, using a modified version of the microscope point technique described by Hamilton and Hall (1975). The subsample was again washed several times with water to remove excess saliva, and then transferred into muslin cloth in order to eliminate water. The resulting biomass was spread thinly at 100 linear plots for identification of grass, stylo and forbs in the diet using a binocular microscope at 15×magnification. A frequency distribution chart was made for each plant species from which the relative frequency in the diet was calculated as a percentage.

The botanical composition of the fodder bank was analysed each time the oesophageal fistula samples were collected except on the 64th and 78th day of sampling when due to logistic reasons no samples were collected. In each paddock, 6 quadrats (1×1 m^2) were thrown at random, in which total herbage was cut and separated in the three components. These were weighed and subsampled for DM content. Proportions were expressed as a percentage of total DM weight. The selectivity index of grass, stylo and forbs was estimated as follows: Selectivity Index: Proportion in the diet (%) divided by proportion in the sward (%).

The other subsample of the extrusa was dried in a forced air oven at 60°C, ground in a laboratory mill fitted with a 1 mm sieve and preserved for chemical analysis. Extrusa samples were analysed for nitrogen using the Kjeldahl method (AOAC 1965) while neutral detergent fibre (NDF) was determined according to the procedures of Van Soest and Wine (1967). Calcium and magnesium was determined by atomic absorption spectrophotometry as described by Pinta (1980). Extrusa dry matter disappearance was estimated using the nylon bag technique as described by Mehrez and Ørskov (1977).

Data on botanical composition (per cent grass and stylo) were transformed to arcsin and analysed according to the general linear model procedure (SAS 1985); the independent variables were grazing period and stocking rate. Duncan's multiple range test (Steel and Torrie 1960) was applied to the transformed means to compare treatment and then transformed back to the original means. Values of nitrogen, NDF, Ca and Mg content and dry matter degradability of extrusa samples were analysed using the general linear model procedure without transformations.

Results

The average floristic composition across fodder banks consisted of 54% grasses, 32% stylo and 13% forbs (Table 1). Fodder banks differed somewhat, bank B having the highest stylo content (45%) and bank C the highest forbs content (19%). Changes over time showed a rapid increase of forbs, whereas grass content declined from about 60% in August to 45% in late October. Stylo became slightly more important towards the end of the season (Table 1).

Table 1. *Botanical composition of pasture swards and diets of goats at four stocking rates on farmers' stylo fodder banks at Abet, Nigeria.*

Fodder bank	Stocking rate (goats/ha)	Grazing period (days)	Grass(%)		Stylo		Forbs (%)	
			Sward	Diet	Sward	Diet	Sward	Diet
A	25	32	61	50	22	48	17	2
	25	46	73	14	20	86	7	0
	23	64	–	31	–	61	–	8
	22	78	–	47	–	53	–	0
	22	92	38	71	46	27	16	2
B	42	32	41	35	47	59	12	6
	42	46	49	17	42	82	8	1
	42	64	–	7	–	92	–	1
	41	78		–	–	74	–	10
	43	92	46	0	46	90	6	10
C	55		70	22	24	74	6	5
	53	46	57	6	20	82	23	0
	51	64	–	8	–	92	–	0
	50	78	–	18	–	74	–	8
	50	92	40	9	30	90	30	1
D	98	32	50	70	48	24	2	6
	83	46	84	31	10	35	6	34
	70	64	–	37	–	42	–	21
	70	78	–	9	–	90	–	1
	68	92	42	29	28	65	30	6

Diet composition of grazing goats was variable (Table 1). However, average values showed that grass content increased with rising grazing pressure, whilst stylo in the diet decreased (Table 2). Across time, trends were less clear. Grass content in the diet were high when in the early stage of growth, decreased during mid season with a upturn towards the end. The average content was 23% ranging from 44% to 16%. A reverse trend was observed for stylo. Early in the season 50% of the diet consisted of stylo rising rapidly to almost 80% in early October to decline when the start of the dry season caused extensive leaf fall (Table 3).

Table 2. *Effect of stocking rate on the mean proportion of grass, stylo and forbs in extrusa of goats grazing stylo fodder banks of farmers at Abet, Nigeria.*

Stocking rate (goats/ha)	% grass	% stylo	% forbs
24	15.6±3.6	79.2±4.6	5.1±2.4
42	10.1±2.4	87.7±3.3	1.7±1.9
52	33.9±7.3	54.2±8.8	11.9±3.7
81	41.3±6.8	56.8±6.8	1.9±1.0

Table 3. *Effect of grazing period on the proportion of grass, stylo and forbs in extrusa of West African dwarf goats grazing stylo fodder banks at Abet, Nigeria.*

Grazing period (days)	% grass	% stylo	% forbs
32	44.3±6.5	51.2± 6.8	4.4±1.9
46	15.8±4.1	77.9±7.3	6.4±4.2
64	19.7±5.3	72.8±8.5	7.5±3.6
78	18.1±4.7	78.5±5.4	3.3±2.4
92	27.0±12.1	68.0±11.9	5.0±1.9

The data of the selectivity index were rather erratic (Table 4), indicating that the relationship between feeds on offer and in the grazed diet was not strong. Preference for grasses was relatively high at low and high stocking rates (0.90), and low at medium stocking rates (0.30). No obvious trend across stocking rates was apparent in the stylo ratings; the average scores ranged from 1.7 to 3.5; goats preferred stylo at all times except in bank D at the start and in bank A at the end of the grazing season (Table 4). On average, the rating of forbs reached unity, but preferences were erratic, indicating that goats went for specific species at a defined stage of growth.

Table 4. *Selectivity indices for grass, stylo and forbs in farmer-managed fodder banks grazed by goats at different stocking rates during the growing season at Abet, Nigeria.*

Fodder bank	Stocking rate (goats/ha)	Grazing period (days)	Grass	Stylo	Forbs
A					
	25	32	0.82	2.16	0.10
	25	46	0.20	4.19	0.00
	22	92	1.88	0.60	0.02
B					
	42	32	0.312	2.99	0.51
	42	46	0.10	4.72	0.04
	42	92	0.22	2.95	1.58
C					
	35	32	0.312	2.99	0.90

	63	46	0.10	4.72	0.00
	50	92	0.22	2.95	0.08
D					
	98	32	0.40	0.51	3.36
	83	46	0.36	3.68	5.54
	68	92	0.68	2.37	0.20

Crude protein declined somewhat with increasing grazing pressure but more steeply from 16.2% to 12.8% with increasing maturity of the herbage (Table 5). The average NDF was 55% and changed little across time or between fodder banks. Dry matter degradability declined with grazing pressure from 74.5 to 67.5% but did not fall with increasing herbage maturity. The upsurge on day 46 (to 77.8%) appears to coincide with a high stylo in the diet of 78% (Table 3). Calcium and magnesium contents were not affected by grazing pressure or date of sampling.

Table 5. *Effect of stocking rate and grazing period on the nutritive value of diets selected by goats grazing stylo fodder banks at Abet in the subhumid zone of Nigeria (% DM*).

SR (goats/ha)	CP	DF	DMD	Ca	Mg
24	14.8a	55.3a	74.5b	1.3a	0.3a
42	14.2a	52.5a	78.6	1.5a	0.3a
52	13.5a	56.8a	70.8c	1.2a	0.2b
81	12.8a	57.7a	67.5d	1.4a	0.3ab
SE	0.85	0.83	1.19	0.09	0.02
GP (days)					
32	16.2a	57.6a	71.7b	1.3a	0.2a
46	13.4ab	52.2a	77.8a	1.5a	0.3a
64	13.6ab	56.2a	71.8b	1.3a	0.3a
78	13.1ab	53.9a	70.Ob	1.4a	0.3a
92	12.8b	57.8a	72.9b	1.2a	0.3a
SE	0.95	2.04	1.26	0.10	0.02

Values with the same superscript are not significantly (P>0.05) different.

DMD = dry matter degradability; SR = stocking rate; GP = grazing period.

Discussion

At all stocking rates goats consistently preferred stylo to grass, probably because legumes contain more protein than grasses. At the higher stocking rate of 52–81 head/ha, goats manifested a higher selectivity for stylo and forbs than for grass (Table 4). Mellado et al (1991) reported similar preferences for goats grazing in a semi-arid region in Mexico.

Langlands and Bennet (1973) reported from studies of Merino sheep grazing pastures that the digestibility of dry matter declined by 4% when the stocking was increased in steps of 20 sheep per hectare. In contrast, the present study shows that there was an initial increase in degraded extrusa by 4% when the stocking rate was increased from 24 to 42 goats/hectare; stocking at 68–98 goats/hectare resulted in a significant decline of over 10% in degradability. However, higher stocking rates resulted in small reductions in the crude protein content in the diets goats, similar to the observation made by Langlands and Bennet (1973).

Conclusions

It has been shown that during the rainy season stylo pasture can be heavily stocked without markedly affecting the composition and nutritive value of the diet. However, the end of the growing season, stylo content of the sward declined from 46% in the two lower to 30% in the two higher rates (Table 1), an optimum rate of 40 goats or 800 kg livestock can safely be recommended. A similar recommendation emerged from other grazing trials, indicating that growth of goats and sustained forage production was assured in paddocks stocked at 800 kg/ha over three months (Ikwuegbu et al 1994).

References

AOAC (Association of Official Analytical Chemists). 1965. *Official Methods of Analysis.* 10th edition. AOAC, Washington, DC, USA.

Hamilton B.A. and Hall D.G.1975. Estimation of the botanical composition of oesophageal extrusa samples. LA modified microscope point technique. *J. Brit. Grassld Soc.* 30:28–34.

Ikwuegbu A.O. and Ofodile S.N. 1992. Wet season supplementation of West African Dwarf goats reared under traditional management in the subhumid zone of Nigeria. In: Ayeni A.O. (ed),*Production System in the Humid Tropics. Proceedings of an International Workshop Held at Obafemi Awolowo University, Ile-Ife, 5–9 June 1992*. Purdo, Wageningen. pp. 195–201.

Ikwuegbu O.A., Tarawali G. and Iji P. 1994. Sustaining a crop–livestock farming system in the subhumid zone of Nigeria by matching feed from improved *Stylosanthes*-based pastures and livestock production. In: de Leeuw P.N., Mohamed-Saleem M.A. and Nyamu A.M. (eds), *Stylosanthes as Forage and Fallow Crop*. ILCA (International Livestock Centre for Africa); Addis Ababa, Ethiopia. pp. 167–174.

Langlands P.J.P. and Bennett I.L.1973. Stocking intensity and pastoral production. II. Herbage intake of Merino sheep grazed at different stocking rates. *Journal of Agricultural Science (Camb)*81:205–209.

Mehrez A.Z. and Ørskov E.R. 1977. A study of the artificial fibre technique for determining the digestibility of feeds in the rumen. *Journal of Agricultural Science (Camb)* 88:645–650.

Mellado M., Foote R.H., Rodriquez A. and Zarate P. 1991. Botanical composition and nutrient content of diets selected by goats on desert grassland in Northern Mexico. *Small Ruminant Research*6:141–150.

Pinta M. 1980. Spectrométrie d'absorption atomique, 2éme édition. Masson, Paris, France.

SAS (Statistical Analytical System). 1985. *SAS User's Guide. Statistics.* SAS Institute Inc. Cary, North Carolina, USA.

Steel R.G.D. and Torrie J.H. 1960. Principles and Procedures of Statistics. McGraw-Hill, London, U.K. 481 pp.

Van Soest P.J. and Wine R.H. 1967. Use of detergents in the analysis of fibrous feeds. IV. Determination of plant cell–water constituents. *J. Asso. Official Analytical Chem.* 50:50–55.

Effet du taux de charge sur la composition botanique et la valeur nutritive des plantes sélectionnées par des chèvres naines d'Afrique de l'Ouest élevées sur des banques fourragères de stylo gérées par les paysans au Nigéria

Résumé

Les petits paysans de la zone subhumide du Nigéria élèvent de petits troupeaux de caprins qu'ils doivent maintenir au piquet ou en espace clos pendant la période de végétation pour les empêcher de s'introduire sur les cultures et de les endommager. Le confinement pendant six mois ou plus réduit la mobilité des caprins et leur consommation alimentaire, entraînant ainsi une baisse de leur productivité. Pour résoudre ce problème, certains paysans ont installé de petites jachères de stylo sur lesquelles ils maintiennent leurs chèvres pendant la période de végdtation. Pour permettre à ces jachères de produire des quantités suffisantes de stylo sur plusieurs années, il convient de déterminer le taux de charge approprié.

Cet article présente les résultats d'une étude du taux de charge conduite en milieu réel sur quatre jachères d'une superficie de 0,1 à 0,16 ha, exploitées par des paysans, sur lesquelles ont été parqudées 24, 42, 52 et 81 chèvres par hectare pendant la période de 3 mois allant d'août à novembre 1992. La composition du pâturage (stylo, graminées et autres herbacées) a été déterminée à trois dates différentes au moyen d'un échantillonnage des parcelles. A ces mêmes dates, la composition botanique et la valeur nutritive des aliments ingérés ont été déterminées à partir d'extrusas contenus dans des fistules introduites dans l'oesophage des chèvres. Les données de la composition du pâturage et des rations ont permis de calculer un indice de sélectivité des trois composantes du parcours.

La prairie était compos2e en moyenne de 32% de stylo, 54% de graminées et 13% d'autres plantes herbacées. Au fil du temps, la part de ces dernières a augmenté alors que celle des graminées a diminué de 60% en août à 45% fin octobre, et que celle du stylo a augmenté lentement indépendemment du taux de charge. Le stylo était à tout moment la plante préférée, sa part passant de 50% des aliments ingérés début septembre à 80% à la mi-octobre avant de baisser dès que la chute des feuilles a commencé. Au cours de la période étudide, Findice de sélectivité du stylo était égal à l'unité avec une moyenne de 2,44 pour l'ensemble des taux de charge et des dates d'échantillonnage.

La teneur en protéines brutes des rations baissait (P<0,05) avec l'accroissement du taux de charge (de 14,8 à 12,8%) et le temps (de 16,2 à 12,8%). Le degré de dégradation, qui atteignait en moyenne 73%, baissait (P<0,05) avec l'accroissement du taux de charge, mais pas au fil du temps. Au vu de ces résultats, un taux de charge optimal de 40 chèvres/ha (800 kg de poids

vif/ha) a été recommandé car il permettrait de garantir une proportion élevée de stylo dans la jachère et dans la ration.

The performance of sheep and goats fed crop residues in addition to limited grazing in the backyards of small-scale peri-urban farmers

A.K.Tuah[1], B.Dzowela[2] and A. N. Said[3]

[1]Dept. of Animal Science, UST, Kumasi, Ghana
[2]ICRAF, Harare, Zimbabwe
[3]1LCA, Addis Ababa, Ethiopia

Abstract

The performances of sheep and goats raised in the backyards of peri-urban farmers were studied. The animals grazed for a limited period of the day (14.00 h to 18.00 h) and were also fed cassava and plantain peels. The animals were weighed every two-weeks. The birth weights of lambs and kids born were where possible recorded together with dates of birth. Weights of animals at birth, 4 months and 12 months were used to calculate pre-and post-weaning growth rates. The quantities of peels of cassava and plantain fed were recorded once a week for 30 weeks. The *in sacco* dry matter degradation and the *in vitro* gas production characteristics of the feeds were also studied.

The mean birthweights of lambs ranged from 1.6 to 3.0 kg, weights of lambs at 4 months and 12 months from 5 to 8 and from 14.2 to 25.5 kg, respectively. The pre-and post-weaning growth rates of lambs varied from 25 to 94 g/day and 12 to 52 g/day, respectively. The preweaning mortality of lambs ranged from 0 to 77%. The birthweights of kids ranged from 1 to 1.6 kg, and weights at 4 months from 5.9 to 8.5 kg. The preweaning growth rates of kids were between 36 and 62 g/day. The preweaning mortality rates of kids ranged from 0 to 9%.

The *in sacco* dry matter and *in vitro* gas production characteristics of the cassava and plantain peels indicated they were good quality feeds. The ratio of cassava to plantain peels fed was 2:1.

Introduction

There are about five million sheep and goats in Ghana. It is the policy of the Ghana Government to increase the production of small ruminants during the implementation of its medium-term agricultural development programme (Ministry of Agriculture 1988). It is envisaged that the sheep population would increase from 2.0 million in 1987 to about 6.4 million in the year 2000 and goat population from about 1.9 million to about 9.2 million in the year 2000. For cattle the corresponding figures are 1.2 million and 1.9 million for 1987 and 2000, respectively.

About 75% of these small ruminants are raised by small-scale rural and peri-urban farmers. This trend in ownership is not expected to change with the envisaged changes in populations. The farmers confine their animals during most of the day in order to prevent damage to crops. The crop farms are now closer to the villages than in the past because of increased human population exerting pressure on arable lands. During the dry season, dry forages may be burnt by bushfires causing serious feed shortages. At present, farmers are feeding crop residues both during the wet and dry season. These crop residues are mostly generated by their own household cooking. Unlike the urban small-scale backyard farmers, they are unable to purchase agro-industrial by-products such as wheatbran, brewers' grains and oil seed cakes to feed their animals due to financial constraints. Most of the crop residues they feed are generally low in nitrogen and possibly minerals and vitamins, especially A and E. Sometimes they also feed limited quantities of foliage of multipurpose trees and shrubs harvested from their farms or along roadsides.

There is a dearth of information on the performance of small ruminants in these small-scale rural and peri-urban farmers. The objective of this monitoring project was to assess the performance of animals belonging to small-scale farmers in a village near the university campus, Kumasi.

Materials and methods

The trial was conducted in Ayeduasi village, which shares borders with the University campus. It is increasingly becoming urbanised because of acquisition of land for building houses by University staff members and other people. The major occupations of the people are crop farming and the raising of small ruminants. Thirteen farmers were initially selected for the study based on their willingness to participate in the programme.

Animals housing, feeding and management

The animals were of different age groups and each farmer owned a few sheep or goats or both. The breed of the sheep was not known since there has been uncontrolled crossing of the dwarf sheep with the larger Sahelian breed. The animals were kept indifferent types of pens, some with and others without roofs. Most of the houses had no side-walls thus allowing rain to fall on the animals. Those with walls were also built up to the roof and lacked proper ventilation. The floors of the pens were of mud and no bedding was provided. The floors were swept daily in the morning but were generally wet; sanitary conditions were poor especially during the rainy season.

The animals were kept indoors for most of the day (until about 1400 h) and were released to graze around the village for about four hours. The animals did not normally move outside the village boundaries because of the limited grazing time available. They were fed crop residues mainly in the morning, These were being kept overnight. The animals were not treated against ecto- and endo-parasites. Sick ones were occasionally treated, when money for drugs was available. The people seem to have forgotten most of local herbs used for treating animals, where many herbs seem to have disappeared.

Breeding was not controlled. Since almost all animals in the village mixed during grazing, sires of lambs and kids were not known.

Data collection

All .animals in the sample were eartagged at the beginning of the experiment together with lambs and kids born during the course. All animals were weighed every two-weeks. Birthweights were recorded where possible. Since the farmers did not have scales and the data collectors were not present, some birthweights were missed. Birth dates however could be remembered by the farmers. Data collection for sheep started in November 1991 and for goats in July 1992.

The quantities of feeds fed to animals in confinement were weighed once a week for 30 weeks starting from November 1991. The feeds were offered and weighed in the evenings, and the refusals the following morning. The feeds were given in feed troughs. Samples of feeds were taken. Mortalities of lambs and kids were recorded.

The *in sacco* dry matter degradation characteristics of the feeds offered were studied using the method of Ørskov et al (1980). The incubation periods were 2, 4, 8, 16, 24, 48, 72 and 96 h. The *in vitro*gas production characteristics of the feeds were studied using the method of Menke et al (1979). Samples of the feeds were analysed for dry matter and nitrogen in accordance with the methods of Association of the Official Analytical Chemists (AOAC 1980) and the Kjeldahl method (AOAC 1980), respectively.

Results and discussion

No statistical analysis was carried out because of the small numbers of animals. The means for each farmer for each parameter were calculated and used in the discussion. The breeds of the sheep were also not the same for all the farms. Only 8 out of the 13 farmers the project started with continued until the end.

The mean birthweights of the lambs for the different farms ranged from 1.6 to 3.0 kg (Table 1). For the kids the mean birthweight ranged from 1 to 1.6 kg (Table 2).

Table 1. *Performance data on lambs.*

Farm no.	Bw (kg)	Ww (kg)	Pre-WGR	Weight 12 mon. (kg)	PostWGR	PreWM
1	2.0	5.0	25	8.0	13	78
2	2.0	6.5	37	13.5	29	0
3	2.0	5.0	25	10.0	19	50
4	2.2	10.5	69	19.0	32	37
5	3.0	14.0	92	21.0	29	67
6	3.0	14.2	94	25.0	47	33
7	1.8	6.4	38	14	32	25
8	2.0	10.6	72	23.1	52	4
9	2.0	6.8	48	10.6	16	19

Bw = Birth weight; Ww: Weaning weight; PreWGR: preweaning growth rate ; Post WGR = Postweaning growth rate ;
Pre-Wm =Preweaning mortalities.

Table 2. *Performance data on kids.*

Farm no.	Bw	Ww	PreWGR
1	1.0	8.5	62
2	1.0	7.0	58
3	1.5	6.5	42

4	1.2	8.0	57
5	1.5	5.9	37
6	1.6	60	38

Bw: birth weight; *Ww:* weaning weight; PreWGR: preweaning growth rate.

Since the animals are weaned naturally, the weight at four months was taken as the weaning weight. The mean weaning weights of lambs ranged from 5 to 14 kg (Table 1).

The heavy lambs (> 10 kg) were Sahel × dwarf cross breeds, whereas those weighing <7 kg were most dwarf breed. For kids, the mean weaning weights ranged from 5.9 to 8.5 kg (Table 2).

The mean preweaning growth rates of the lambs ranged from 25 to 94 g/day (Table 1). The mean preweaning growth of the kids ranged from 36 to 62 g/day (Table 2). The mean weights of lambs at 12 months ranged from 10 to 26 kg (Table 1) with mean postweaning growth rates ranging from 12 to 52 g/day. There were no corresponding weights for kids as none reached 12 months at the end of the monitoring period.

Out of the 115 lambs born during the study, 16 (7.5%) were as twins (Table 1). For the 53 kids born (Table 2) 24 (45.3%) were as twins and three were born as triplets (5.67).

The preweaning mortality rates of the lambs ranged from 0 to 77% while those of kids ranged from 0 to 9%.

All farmers fed cassava and plantain peels daily at a ratio of about 2:1. Only five farmers fed foliage of *Ficus exasperata* on one occasion each during the trial. The intakes of forage could not be measured. Assuming that all animals between 4 and 12 months consumed about half the quantity of these supplements supplied as adults, the quantities of the peels eaten per adult ranged from 124 g/head/day to 30 g/head/day on dry matter basis. Since the quantities of grass consumed were not known it is difficult to calculate what percentages of feed intake these figures represent. It however seems that the animals were adequately fed because of their performance. The forages consumed might have supplied enough nitrogen minerals and vitamins which mostly likely were deficient in the peels.

The plantain peels were also green and were mostly likely rich in vitamin A precursors.

The *in sacco* degradation and the *in vitro* gas production characteristics of the feeds indicate that they are at least higher in digestible dry matter, and hence organic matter or energy (Table 3) than cereal straws (A.K.Tuah, D.B. Okeni and F.Y. Obese, unpublished data).

Conclusions

The performance of sheep and goats in the backyard farms of the peri-urban small-scale farmers compared favourably with the reported performance of these two species on the university farm, Kumasi.

Until further restrictions are placed on these animals with respect to grazing, their productivity may not be reduced with the restricted grazing time and present level of supplementation of the diets with cassava and plantain peels. The high mortality rates of the lambs, however, need further investigation. There is also the need to conduct research into housing problems.

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References

AOAC (Association of Official Analytical Chemists). 1980. *Official Methods of Analysis.* 13th edition. AOAC, Washington, DC, USA.

Menke K.H, Raab L., Salewski A., Steingass H., Fritz D. and Schneider W. 1979. The estimation of the digestibility and metabolizable energy content of ruminant feeding stuffs from the gas production when they are incubated with rumen liquor *in vitro. Journal* of *Agricultural Science (Cambridge)* 93:217–222.

Ministry of Agriculture 1988. *Medium Term Agricultural Development Programme.* Working Paper 4. Livestock subsector. Ministry of Agriculture, Accra, Ghana.

Ørskov E.R., Hovell F.D. and Mouhl F.1980. *Tropical Animal Production* 5: 195–213.

Performances d'ovins et de caprins de basse-cour recevant des résidus de récoltes en plus d'un pâturage limité chez les petits paysans des zones péri-urbaines

Résumé

Les performances d'ovins et de caprins élevés en basse-cour par les petits paysans des zones péri-urbaines ont été étudiées. Les animaux ont pâturé pendant une durée limitée au cours de la journée (de 14 à 18 heures) et ont reçu des pelures de manioc et de banane plantain. Ils ont été pesés toutes les deux semaines. Les poids à la naissance des agneaux et des chevreaux ont, dans la mesure du possible, été enregistrés avec leur date de naissance. Les poids à la naissance, à 4 mois et à 12 mois ont été utilisés pour calculer les taux de croissance avant et après sevrage. Les quantités de pelures de manioc et de banane plantain distribuées ont été enregistrées une fois par semaine pendant 30 semaines. Les caractéristiques de la dégradation *in sacco* de la matièe sèche et celles de la production *in vitro* de gaz ont également été étudides.

Les poids des agneaux variaient de 1,6 A 3 kg à la naissance, de 5 à 14,2 kg à 4 mois et de 8 à 25,5 kg à 12 mois. Leurs taux de croissance avant et après sevrage allaient respectivement de 25 à 94 g/j et de 12 à 52 g/j et leur mortalité avant sevrage variait de 0 à 78%. Quant aux chevreaux, leur poids à la naissance variait de l à 1,6 kg, et leur poids à 4 mois de 5,9 à 8,5 kg. Leur taux de croissance avant sevrage allait de 36 à 62 g/j et leur taux de mortalitd avant sevrage de 0 à 9%.

Les caractéristiques de la dégradation *in sacco* de la matière sèche et celles de la production *in vitro* de gaz indiquent que les pelures de manioc et de banane plantain, servies dans un rapport de 2 à 1, sont des aliments du bétail de bonne qualité.

List of Participants

Benin
Dr C.C. Adandedjan
UNB/FSA
B.P. 526
Cotonou
Benin
Tel: 36 0218
Tlx: 5020 UNB Cotonou

Botswana
Mrs J. Macala
Department of Agricultural Research
Animal Production Research Unit
P/Bag 0033
Gaborone
Tel: 359780
Fax: 373847/8 SACCAR

Dr Berhane Kiflewahid
Department of Agriculture
P. Bag 0033
Gaborone
Fax: 2752 SACCAR BD
Fax: 375204

Cameroon
Dr A. Njoya
Institute of Animal and Veterinary Research
P. O. Box 1073
Garoua, Cameroon
Fax:237. 272139
Tel: 237. 272084

Dr R.M. Njwe
Country Representative
Heifer Project International
B.P. 467

Côte d'Ivoire
Mr B. C. N'guessan
IDESSA
B.P. 633
Bouake 01
Côte d'Ivoire
Tlx: 69103 FREIGH CI
Fax: 225 632045
Tel: 633369

Ethiopia
Dr Daniel Keftasa
Alemaya University of Agriculture
Agricultural Research Center
Debre Zeit, Ethiopia
Fax: 251. 1 338061
Tel:25. 1. 338555

Ghana
Mr P. Barnes
Animal Research Institute
P. O. Box 20
Achimota, Accra
Ghana
Tlx: 2195 DPAC GH
Tel: 027. 554744

Mr N. Karbo
Animal Research Institute
Nyankpala Station
P. O. Box 52
Nyankpala . Tamale
Ghana
Fax; c/o GGAEP (00071 2870)

Prof A.K. Tuah
University of Science & Technology

Bamenda, Cameroon
Fax: 237 363921/363822/363284
Tel: 237 363822

Dr E.T. Pamo
Dschang University Centre
Department of Animal Science
P.O. Box 222
Dschang
Cameroon
Fax: 237. 451202
Tlx: 7013 KN
Cameroon

Department of Animal Science
Kumasi
Ghana
Tlx: 2555 GH
Fax: 233 . 51. 60137
Tel: 775180

Dr J.F. Fleischer,
Department of Animal Science
University of Ghana
P. 0. Box 26
Legon . Accra, Ghana
Fax: 775306
Tlx: 2556 UG GH

Kenya

Mr E.M. Nyambati
KARI
P.O. Box 450
Kitale
Kenya

Dr J.G. Mureithi
Kenya Agricultural Research Institute
P.O. Box 57811
Nairobi
Kenya

B. Kayongo
University of Nairobi
P. 0. Box 29053
Nairobi
Kenya
Tel: 02 . 632211

E.M. Kiruiro
Kenya Agricultural Research Institute
P. 0. Box 27
Embu

Madagascar

Mr A.S. Raveloson
FIFAMANOR
B.P. 198 Ansirabe
Madagascar
Fax: 34902
Tlx: 22211 SEAL

Malawi

Dr G. Kanyama-Phiri
Bunda College of Agriculture
P.O. Box 269
Lilongwe, Malawi
Fax: 265 . 277251 . Tel: 277222

Mali

Dr M. Togola
I.E.R.
B.P. 258
Bamako, Mali

Kenya
Tel: 0161 . 20116/20873

Mr L. M. Mogaka
KARI
P.O. Box 523
Kisii
Kenya
Tel: (381) 20527

Dr A.B. Orodho
KARI
P.O. Box 169
Kakamega, Kenya
Fax: 0331 20893
Tel: 0331. 30031/30039/20893

Dr J. Wandera
KARI
P. O. Box 450
Kitale, Kenya
Tel: 20107/8/9

Lesotho

Mr J.W. Ng'ambi
National University of Lesotho
P. O. Box Roma 180
Lesotho
Tel: Roma 340577
Tlx: 430310
Fax: 34000

Senegal

Dr M. Cissé
ISRA-LNERV
B.P.2057
Dakar
Sénégal

Sudan

Fax: (223) 223775
Tel: (223) 222413

Nigeria

Dr C.F.I. Onwuka
University of Agriculture
Dept. of Animal Science
PMB 2240
Abeokuta, Ogum State
Nigeria
Fax:234 . 39 . 234650
Tlx: 24676 UNAAB NG

Dr E.C. Agishi
Benue State University
PMB 102119
Makurdi
Nigeria
Tel: 44 . 33811 Res: 44 31886

Rwanda

Dr P. Kamatali
Faculté d'Agronomie
Université Nationale du Rwanda
B.P. 117
Butare, Rwanda
Fax: 250 823
Tel: 250 228

Togo

Mr P. Agbemelo Tsomafo
B.P. 1515
Lome, Togo
Fax:228. 218595
Tel: 254197

Uganda

M. Tagelsir Ahmed
University of Khartoum
P. O. Box 32
Khartoum North
Sudan
Fax: 77973
Tel: 77615
Tlx: 22585 BADRO

Swaziland

Mr B. Xaba
Malkems Research Station
4 Malkerns
Swaziland
Fax: 47000
Tel: 83258/83017

Tanzania

Dr A.E. Kimambo
Department of Animal Science and Production
Faculty of Agriculture
Sokoine University of Agriculture
P. O. Box 3004
Chuo Kikuu, Morogoro
Tanzania
Fax: 056 4562
Tel: 056 4617

Mr P.X. Kapinga
Livestock Research Centre
P. 0. Box 5016
Tanga
Tanzania
Tel: 44350

Dr N.A. Urio
Sokoine University of Agriculture
P. 0. Box 3004

Dr E.N. Sabiiti
University of Makerere
Faculty of Agriculture and Forestry
P. 0. Box 7062
Kampala, Uganda
Fax: 41 550680 or 41 531641

Dr F. Bareeba
University of Makerere
Faculty of Agriculture and Forestry
P. O. Box 7062
Kampala,
Uganda
Fax: 41 550680 or 41 531641

Mr P. Lusembo
Namulonge Research Station
P. O. Box 7084
Entebbe, Uganda
Fax: 256. 531641

CIRAD-EMVT

Dr P. Fabregues
CIRAD EMVT
10 Rue P Curie
Paris, France
Fax: 1 43 75 23 00, France
Tlx: 262017
Tel: 1 43 68 88 74

NRI-England

Dr D. Silverside
NRI
Chatham Maritime
Kent
U.K.
Fax: 44. -1634. 880066/77
Tel: 44. 1634. 880088

Chuo Kikuu, Morogoro
Tanzania
Fax: 056 4562
Tel: 056 4617

Mrs D.M. Mgheni
Sokoine University of Agriculture
P. O. Box 3004
Morogoro
Tanzania
Fax: 255. 56. 4562
Tel: 255. 56. 4617
Tlx: UNIVMOG 55308

Zimbabwe

Mr P. Nyathi
Dept. of Research and Specialist Services
P/Bag 8108
Causeway, Harare
Zimbabwe
Fax: 728317
Tel: 704531

Dr L. M. Sibanda(Mrs)
Linds Agricultural Services
P.O. Box MP 546, Mount Pleasant
Harare, Zimbabwe
Tel: 263 4 885590

Dr J.H. Topps
University of Zimbabwe
P. O. Box MP 167
Mt. Pleasant, Harare
Zimbabwe
Tel: 303211

Dr S. Sibanda
University of Zimbabwe
P.O. Box MP 67
Mt. Pleasant, Harare

Dr D. Romney
NRI
Chatham Maritiime
Chatham
Kent MT4 4TB
U.K.
Fax: 1634. 880066/77
Tel: 1634. 880088

SIDA

A. Kartzow
Regional Soil Conservation Unit
P. 0. Box 30600
Nairobi
Fax: 338612
Tel: 229042
Tlx: 25582 RSCU Nbi

ICRAF

Dr B. H. Dzowela
SADC/ICRAF Agroforestry Project
P. 0. Box 8108
Causeway, Harare
Zimbabwe

J. Ndungu
P. O. Box 30677
Nairobi, Kenya
Fax: 2. 521001
Tel: 2. 521450
T1x:22048ICRAF

ILCA now ILRI

Dr E.A. Olaloku
ILRI
P. O. Box 5689

Zimbabwe

R. Muchadeyi
Grasslands Research Station
P/Bag 3701
Marondera
Zimbabwe
Tel: 3526/7/8

Mr J. F. Mupangwa
AGRITEX
P. O. Box 8117
Harare
Zibambwe
Tel: 753680

M. M. Chiimbira
P. O. box 973
Bindura
Zimbabwe
Tlx: 3441 Mt. Darwin

L. Houe
Dept. of Research and Specialist Services
Makoholi Research Station, Masvingo
P. Bag 9182
Masvingo
Zimbabwe
Tel: 263. 39. 63255

A. Mutongerwa
P. 0. Box 22
Murombedzi
Zimbabwe
Tel: 27920 Chegutu

A. Sibanda
DDP Marirangwe
P. O. Box 5055

Addis Ababa
Ethiopia
Fax: 251. 1. 611892
Tel: 251. 1. 613215
Email: ilri-ethiopia@cgnet.com

Dr J. Ndikumana
ILRI
AFRNET Coordinator
P. O. Box 30709
Nairobi
Fax: 254. 2. 631499
Tel: 254. 2. 630743
Email: j.ndikumana@cgnet.com

Dr M. Sall
ILCA Representative
P. O. Box 60
Bamako
Mali

Prof J. Kategile
P.O. Box 1755 Morogoro
Tanzania
Tel. 056-3707

Harare, Zimbabwe
Tel: 2365

Mr T.N. Mutukumira
University of Zimbabwe
P. O. Box MP 167
Mt. Pleasant, Harare
Zimbabwe
Fax: 732828
Tel: 303211 Ext. 1446

Dr P. Chigaru
ARA-Techtop Consulting Services
P. O. Box 4555
Harare, Zimbabwe
Fax: 263. 4. 793054
Tel: 263. 4. 731581
Tlx: 24572

Dr L. Ndlovu
University of Zimbabwe
P.O. box MP 167
Mount Pleasant
Harare, Zimbabwe
Fax: 263. 4. 732828
Tel: 263. 4. 303211
Tlx: 26580 UNIV