CATTLE FEEDING AND PRODUCTION IN THE SOUTHERN HIGHLANDS OF TANZANIA

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ABSTRACT

The Southern Highlands region is being given particular attention in a thrust to increase dairy production in Tanzania, with an emphasis on the use of improved cattle. For the past 15 years, most of the livestock research programmes at Uyole Agricultural Centre (UAC) have been aimed at increasing milk production in the region. In this paper, research on improved cattle production, particularly that on feeds and feeding, is reviewed. Emphasis is placed on the effect of weather conditions, season and age of plants on the nutritive value of forages, the problems of dry season feeding, and the use of supplementary feeding. The constraints faced by smallholder farmers in the region are discussed. In addition, an attempt is made to prioritize the sequence of innovations for introduction to farmers. Future research priorities are highlighted.

INTRODUCTION

Agriculture is the mainstay of the economy of Tanzania. Approximately 90% of the total population is engaged in this sector. It accounts for more than 50% of the gross national product. The livestock industry has contributed relatively little by comparison with crops, possibly because preferential emphasis has been placed on crops in research and extension work (Anon., 1984). However, the need to raise people's standard of living by increasing their income and level of nutrition means that there is a corresponding need to develop the livestock industry (Anon., 1982).

The Southern Highlands region of Tanzania is renowned for its enormous agricultural potential. Covering 26% of the country's total land area, it produces about 46% of Tanzania's total maize crop (Moshi, 1991), and has 15% of the total cattle population (MALD, 1986). The ratio of cattle to the human population is 0.44, 0.67, 0.65 and 0.06 for Iringa, Mbeya, Rukwa and Ruvuma Regions, respectively (Smith, 1990). However, of the total of 1.8 million cattle, about 99% are indigenous Tanzanian shorthorn zebu (Table 1), which are characterized by low production coefficients, especially for milk. Thus the region's self-sufficiency gap for milk production is wider than for meat.

The region's potential for dairy production is recognized and for the past 20 years great emphasis has been placed on increasing the supply of improved cattle (Anon., 1983). The demand for such animals has been increasing year by year. The attempt by many Tanzanians to reduce their economic hardship, and the increasing demand for milk, may have accelerated investment in more productive systems. However, as in other areas of the country, factors such as poor nutrition and disease are major constraints on cattle productivity. Animal health problems such as tick-borne diseases and parasites are an important cause of poor productivity and high mortality. The majority of cattle depend mainly on natural pastures and crop residues, which have a nutritive value that is usually below the level required for production.

The aim of this paper is to review research on improved cattle production, with particular emphasis on animal nutrition, to catalogue the current practices of, and the constraints faced by, smallholder farmers in the region, to prioritize improved practices for introduction to the farmers, and to provide guidelines for future research.

Table 1. Total cattle numbers in the Southern Highlands of Tanzania

Region	District	Indigenous	Improved dairy	Improved beef	Total
Iringa	Iringa	238 341	2 394	813	241 548
	Ludewa	29 518	156	0	29 674
	Makete	20 640	2 078	200	22 918
	Mufindi	70 251	1 498	1 019	72 768
	Njombe	110 872	2 187	443	113 502
Mbeya	Chunya	125 365	0	0	125 365
	Ileje	33 933	48	0	33 981
	Kyela	37 128	115	0	37 243
	Mbeya	483 034	2 049	140	485 223
	Mbozi	168 911	272	1	169 184
	Rungwe	47 766	1 982	55	49 803
Rukwa	Nkasi	44 245	173	69	44 487
	Mpanda	104 538	567	163	105 268
	Sumbawanga	241 180	429	870	242 479
Ruvuma	Mbinga	29 620	325	45	29 990
	Songea	5 975	829	599	7 403
	Tunduru	1 374	226	17	1 671
Total		1 792 691	15 328	4 434	1 812 507

Source: MALD, 1986.

RESEARCH REVIEW

Source of improved cattle

To encourage the use of exotic breeds and their crosses with indigenous cattle, a number of livestock multiplication units have been established. According to Kyambwa (1986), about 5,000 F_1 heifers are produced annually (the national demand is estimated at 8,000 heifers). To supplement the supply of crosses, exotic dairy cattle have been imported, mainly for use on government owned farms.

In 1984, there were about 20,000 improved cattle in the Southern Highlands (MALD, 1986; Table 1). Since then, a significant number of both exotic and crossbred cattle has been sold to smallholders. The main sources of the animals include the livestock multiplication units (LMUs) operating in Iringa (at Sao Hill), Rukwa (at Nkundi) and Ruvuma (at Hanga) and four large scale dairy units in Iringa (Ihimbo and Kitulo Dairy Farming Company, DAFCO, Farms) and Mbeya (Iwambi DAFCO Farm and Uyole Agricultural Centre, UAC). Since 1979, UAC has sold a total of 518 cows and 191 bulls to smallholder farmers (up to June 1992).

A number of donor agencies has been helping the extension services of the four regions of the Southern Highlands to develop their dairy industry by running the LMUs and selling improved cattle to farmers, usually at subsidized prices. The Small Scale Dairy Development Project (SSDDP), a joint venture between the Government of Tanzania and the Swiss Federal Council, operates in Iringa and Mbeya Regions. The Word Food Programme (WFP) is helping in Rukwa and Ruvuma Regions.

The performance of imported breeds and crossbred animals is usually better than that of traditional zebu (Syrstad, 1986). Our preliminary results from a survey conducted in the Southern Highlands support this finding (Table 2). However, Mgheni and Peterson (1986) and Preston and Leng (1987) have reported that genotype-environment interactions have a major influence on the productivity of animals, and that environmental stress, caused for example by poor nutrition and disease, limit the expression of the genetic potential of exotic pure-bred animals. Studies by Preston *et al.* (1970) on the performance of zebu cattle and crosses indicate that when nutrition is a limiting factor there is no advantage in using the genetically superior crossbred rather than the local (unimproved) zebu. Results from the Mbeya Region Small Scale Dairy Recording Scheme emphasize the importance of improved nutrition for crossbred and purebred animals (Table 3). Significant effects on milk yield are obtained when both improved fodder and concentrates are provided.

Table 2. Mean daily milk yield (l) of traditional (zebu) and improved (crosses and pure breeds) cattle in the Southern Highlands of Tanzania

Region	No. farmers interviewed	Zebu		Crosses		Pure breed	
		No.	Yield	No.	Yield	No.	Yield
Iringa	199	219	1.5	44	7.4	-	-
Mbeya	268	215	2.5	29	7.4	16	16.0
Rukwa	114	87	3.3	7	5.0	-	-
Ruvuma	75	9	2.4	4	5.0	-	-

Source: Mbwile *et al.*, 1992.

Table 3. Effect of improved fodder and concentrates on milk yield in Mbozi and Rungwe districts in Mbeya Region[1]

	Mean daily milk yield cow^{-1} day^{-1} (l)					
	Mbozi District			Rungwe District		
	Crosses	Purebred	Combined	Crosses	Purebred	Combined
Without improved fodder	4.5	8.7	6.3	5.7	9.3	8.3
With improved fodder	5.5	9.4	7.2	7.4	9.9	9.2
Without concentrate	3.4	5.6	4.8	5.6	8.0	7.5
With concentrate	5.9	9.3	7.2	7.5	10.5	9.8

[1] Comparisons are valid only between means within same district and type of feed.
Source: Mchau *et al.*, 1985.

The effects of genotype-environment interactions must therefore be taken into account when planning livestock development strategies. Our experience in the Southern Highlands indicates that, although purebred animals have the greatest potential for milk production, limited availability of good quality feeds and poor husbandry practices limit the yields achieved. It is partly for this reason that crossbred animals are often recommended.

Nutritional value of forages

The weather conditions in the Southern Highlands of Tanzania are characterized by high temperatures and a high soil moisture level at the start of the growing season, and by decreasing night temperatures and moisture towards the end of the season and during the early part of the dry season. Soil moisture is often almost depleted by the end of the dry season. These changes greatly affect forage growth and quality (Mbwile, 1990). The results of a study on the effects of harvest date on the growth and nutritive value of Rhodes grass (*Chloris gayana*) are shown in Table 4. Variations in the measured parameters correlated better with variations in temperature and solar radiation than with rainfall. Growth rate and the content of cell wall constituents tended to decrease with decreasing temperatures and increasing solar radiation, while crude protein content and *in vitro* organic matter digestibility (IVOMD) seemed to increase with decreasing temperatures and/or increasing solar radiation. The results for the content of cell wall constituents in relation to temperature and light intensity confirm the findings of Deinum and Dirven (1972), but conflicting observations have been reported on the effect of moisture on fibre content. A review by French (1957) suggested that lack of water leads to rapid lignification and the work of Pitman *et al.* (1983) on Klein grass supported these findings. Conversely, Miller and Cowlishaw (1976) reported that the levels of crude fibre in *Digitaria* spp during a severe dry period remained the same as those in the rainy season.

Mbwile (1990) showed that plant age has a significant effect on growth rate, chemical composition and digestibility of Rhodes grass (Table 5). The mean growth rate changed from 48 to 63 kg of dry matter a hectare a day between four and ten weeks of age. Crude protein levels decreased with age at a rate of 0.2% a day in leaves and 0.23% in stems. The proportion of cell wall constituents increased with age, with a greater increase in stems (0.26%) than in leaves (0.08%). *In vitro* organic matter digestibility decreased with age at a daily rate of 0.17% in leaves and 0.38% in stems. The decline in the nutritive value of Rhodes grass with age has previously been reported by Milford and Minson (1968) and Reid *et al.* (1973).

Table 4. Correlation of environmental factors with the growth rate, crude protein, cell wall constituents as measured by neutral detergent fibre, and *in vitro* organic matter digestibility (IVOMD) of Rhodes grass at four different stages of growth, 1987/88

Age (wks)	Rainfall	Max. temp.	Min. temp.	Radiation
		Growth rate		
4	-0.27	-0.22	0.07	-0.37
6	-0.12	0.77**	0.55	-0.25
8	0.32	0.82**	0.82**	-0.79**
10	0.58	0.82**	0.84**	-0.88**
		Crude protein		
4	-0.14	-0.63	0.27	0.10
6	0.27	-0.64*	-0.16	-0.03
8	0.27	-0.63	-0.07	0.19
10	0.12	-0.14	0.11	0.12
		Cell wall constituents		
4	-0.32	0.24	-0.62	0.36
6	0.03	0.55	0.33	-0.12
8	-0.22	0.67*	0.45	-0.44
10	0.77**	0.81**	0.89**	-0.87**
		IVOMD		
4	0.52	-0.74**	0.06	-0.20
6	-0.39	0.02	-0.18	0.26
8	-0.50	-0.17	-0.60	0.74**
10	0.19	-0.39	-0.09	0.29

*, ** denote a significant correlation at P<0.05, and 0.01, respectively.
Source: Mbwile, 1990.

Table 5. Effect of age on growth rate (kg dry matter ha^{-1} day^{-1}), crude protein, cell wall constituents and *in vitro* organic matter digestibility (IVOMD) of Rhodes grass

	Age (weeks)			
	4	6	8	10
Growth rate	47.6	56.1	66.9	63.2
		Crude protein		
Leaves	19.9	16.8	13.9	11.7
Stems	14.4	10.5	7.2	4.8
Whole plant	17.4	14.1	11.6	9.1
		Cell wall constituents		
Leaves	62.9	63.2	65.1	66.2
Stems	65.2	67.6	71.0	76.0
Whole plant	64.0	65.7	67.6	69.0
		IVOMD		
Leaves	85.1	82.6	79.9	78.1
Stems	79.0	73.5	67.2	62.8
Whole plant	81.1	77.9	74.2	67.6

Source: Mbwile, 1990.

The growth and quality of Rhodes grass was significantly affected by the date that growth commenced, with a decline in growth rate from 88 to 36 kg dry matter a hectare a day between the first and the last period of regrowth. The correlation of crude protein content with the day of season was only significant in leaves of four and six week-old forages.

Selective consumption

Mbwile (1990) showed that when cattle were offered increasing levels of feed, the amounts they refused differed with the growth stage of the Rhodes grass. The leaf/stem ratios, content of crude protein and *in vitro* organic matter digestibility were lower, and cell wall constituents higher, in the refused fodder. The intake of leaves and stems increased with increasing levels of feeding but decreased as the forage aged. The results indicate that if mature forage is the only feed offered, at least 30% wastage is inevitable. These findings agree with those of other workers in the tropics (Zemmelink, 1980; Aboud, 1990).

Dry season feeding

Unavoidable seasonal fluctuations in growing conditions mean that periods of excess supplies of forage alternate with periods of shortage. In many areas in the Southern Highlands, the period of plenty lasts for 5-6 months and the period of scarcity for 6-7 months (Mbwile and Madata, 1984). Conservation and storage of feed is therefore a critical issue. Standing hay and crop residues are the main feeds used. Hay and silage are used mainly on large scale farms where there is the necessary machinery and skill.

Standing hay

Standing hay, or forage that has matured *in situ* after the end of the rainy season, is the cheapest form of conserved forage and the most widely used, especially under traditional extensive grazing conditions (Mbwile and Madata, 1984). Kategile (1980) estimated an annual production of about 10 million t of standing hay in Tanzania (about 2 million t of it in the Southern Highlands). Preliminary results of a survey in the Southern Highlands indicate that this is the most important feed, even for improved cattle (Mbwile *et al.*, 1992).

The greatest limitation to the use of standing hay as a feed is its poor nutritive value. It has a low nitrogen content and a high degree of lignification of the cell walls (Van Soest, 1982), leading to low digestibility and intake. Thus, although the hay is of great value as a feed reserve during the dry season, it is only adequate for production systems that can accept low levels of production. Reports of attempts to improve production and utilization of standing hay in the literature are limited. Physical, chemical and biological delignification methods that have been used to improve the feeding value of crop residues and other fibrous by-products (described by Kategile *et al.*, 1981 and Stundstol, 1988) should apply to standing hay. However, a treatment technology that is appropriate for the existing feeding system in the region is required.

Harvesting standing hay at appropriate times and storing it properly could improve the value of the crop. Under favourable circumstances, such as occur at the end of the rainy season in the Southern Highlands, standing hay can provide roughage of moderate quality. The rate of decline in quality with age is slow during the cold period (May to August, Mbwile, 1990), so that this period could be used for harvesting and storage. As temperatures increase and soil moisture becomes depleted late in the dry season, the rate of decline in quality is likely to increase.

Crop residues

Crop residues are plentiful in the Southern Highlands, particularly maize, sorghum, millet and rice straw, legume crop by-products, and dried stalk material from such crops as sunflower. The value of these by-products as livestock feed is fully appreciated and crop residues rank second after standing hay as dry season feed (Mbwile *et al.*, 1992). The most common practice is to let animals into the fields after the grain has been harvested (stubble grazing). The advantage of this method is that no handling or storage of the material is needed. However, a greater proportion is spoiled through contamination with soil and manure. Transporting crop residues to the animals would help avoid this loss, but there has been little been research on alleviating problems that may be associated with the handling and storage of crop residues.

Crop residues are generally of poor quality (Kategile *et al.*, 1981). Their intake and digestibility is limited by a low nitrogen and high fibre content. Most crop residues contain less than 6% crude protein and 7.5 MJ of metabolizable energy kg^{-1} dry matter and have digestibilities below 50% (Said and Peters, 1990). In recent years a great deal of research has been conducted on the improvement of crop residues by chemical and biological treatment (Kategile *et al.*, 1981; Stundstol, 1988) but, as pointed out by Reed *et al.* (1988), there has been little adoption of the technology by farmers worldwide. Improvement through genetic selection has met with criticism. Many people feel that such improvement should not be at the expense of grain yield and quality (Reed *et al.*, 1988). Owen *et al.* (1989) suggested another approach might be to accept selective consumption. The work of Zemmelink (1980), Aboud (1990) and Mbwile (1990) support this idea.

Green forages

At UAC, lupins and oats remain green until the end of August or September depending on the date of planting. Results comparing the dry matter intake and digestibility of lupins and oats for sheep are shown in Table 6. The animals consumed more oats than lupins, possibly because of the low dry matter and high alkaloid content of lupins (Mbwile and Wiktorsson, 1982). The digestibility of lupin was less affected by age than that of oats. Until mid-September the digestibility of both forages was still quite high (70 and 66% for lupins and oats, respectively).

Table 6. Effect of plant age on dry matter (DM) content (%), intake (g kg^{-1} body $weight^{0.75}$), and digestibility (%) of lupins and oats fed green to sheep

Days from planting		DM content		DM intake		DM digestibility	
Lupins	Oats	Lupins	Oats	Lupins	Oats	Lupins	Oats
79	101	15.0	15.0	53.0	43.3	76.3	75.8
89	111	17.4	21.0	43.2	74.1	75.3	78.8
99	121	19.1	21.4	53.0	76.2	75.2	71.8
109	131	18.4	24.6	44.9	74.3	76.5	71.0
119	141	18.7	30.2	35.1	64.0	69.3	65.7
129	151	19.5	30.6	35.9	65.1	69.5	67.0
139	161	22.5	35.6	27.4	74.9	67.4	69.6
149	171	25.3	43.2	46.3	69.2	70.4	65.9

Source: Mbwile and Madata, 1984.

Hay and silage

Comparative studies on Rhodes grass hay, Rhodes grass silage, *Desmodium intortum*/Rhodes grass silage, and maize silage were carried out at UAC from 1978 to 1991. The silages were well preserved and quite stable, but the pH value (a standard measure of quality) of the desmodium/Rhodes grass, Rhodes grass first cut and Rhodes grass second cut silages were 4.9, 4.9, and 5.1, respectively (Mbwile and Wiktorsson, 1982). Only maize silage had an average pH of 3.8, equivalent to that of good quality temperate silage. Similar results have been reported by Davies (1963), Miller (1969) and Catchpoole (1970).

The dry matter digestibility of the silage was 60-61% for the desmodium/Rhodes grass mixture and Rhodes grass first and second cut, and 68% for maize (Mbwile and Wiktorsson, 1982). Intake of hay was higher than that of silage (Table 7), as found in temperate countries (Murdock and Rook, 1963; Campling, 1966). However, the higher intake of pure Rhodes grass silage compared with mixed desmodium/Rhodes grass silage differed from findings in temperate climates (Ekern and Vik-Mo, 1979). When the pure and mixed forages were fed green to dairy cows and sheep in a digestibility trial at UAC similar results were obtained, with a daily dry matter intake of 9.4, 10.7 and 14.4 kg dry matter per cow for animals fed on desmodium/ Rhodes grass, Rhodes grass, and Rhodes grass plus 5 kg concentrate, respectively (Mbwile *et al.*, 1981). One explanation for the lower intake of the desmodium/Rhodes grass mixture might be its lower digestibility (Mbwile *et al.*, 1981; Mbwile and Wiktorsson, 1982; Madata, 1982).

Cows fed on maize silage showed the smallest dry matter intake (Table 7), perhaps because the silage tends to turn mouldy after opening and because of its acidity (Harris *et al.*, 1966).

There were no significant differences among the forages in their effect on milk production, except in 1979 when the milk production of cows fed on maize silage was significantly lower, possibly because of a reduced dry matter intake. Milk production from silage is higher than from hay in temperate climates (Murdock and Rook, 1963, Burstedt and Lingvale, 1977), but there is little information for Tanzania.

Table 7. Mean daily dry matter intake (kg cow^{-1}) of hay and silages, 1978-1981

	1978	1979	1980	1981
Rhodes grass hay	8.4	6.4	7.6	-
Rhodes grass silage7.8	5.7	8.6	9.4	
Desmodium/Rhodes grass silage	7.5	5.2	7.2	7.9
Maize silage	5.3	5.0	6.3	6.9

Source: Mbwile and Maro, 1983; Mbwile and Wiktorson, 1982.

Supplementary feeding

Many authors have reported that the productivity of cattle maintained on tropical pastures and crop residues is poor and erratic (Stobbs, 1971; Van Soest, 1982), but can be improved by judicious supplementary feeding of concentrates and minerals (Jeffery, 1971). Improvement in intake and digestibility of poor quality roughages by nitrogen and energy supplementation has been reported (Forbes, 1986; Fadel *et al.*, 1987; Preston and Leng, 1987). Goodchild (1981), using zebu calves aged 6-18 months grazing on standing hay in central Tanzania, obtained a significant response to nitrogen supplementation: 10-20 g live-weight gain per g of nitrogen in the supplement.

Young Friesian heifers aged 5-7 months fed maize silage (6.6% crude protein) as a basal diet did not show any change in weight gain when urea was added to the roughage (Table 8). The addition of molasses as urea molasses solution or urea molasses cake improved the uptake of urea, resulting in a significantly higher weight gain. The animals on balanced calf concentrate performed best in terms of weight gain. The roughage intake was highest in molasses-based diets, and all forms of urea preparations gave better economic returns (weight gain per unit cost of supplement) than calf concentrate. The cost of high protein supplements has led other workers to investigate the use of forage legumes as a protein supplement (Milford and Minson, 1968; Flores *et al.*, 1979; Van Eys *et al.*, 1986; Mero and Uden, 1990). However, despite the resulting increase in crude protein intake, the legumes do not stimulate the intake of poor quality roughage (Flores *et al.*, 1979; Van Eys *et al.*, 1986; Mero and Uden, 1990). Further studies are required.

In Tanzania, the amount of concentrate offered to cattle is variable; usually high levels of concentrates are given to exotic breeds and small amounts or none to crossbred or traditional cattle. Mbwile *et al.* (1991) showed that cows on a high level of nutrition produced significantly more milk than animals given a low and medium level of concentrates. There was no significant difference in milk yield between the low and medium feeding regime except for first calvers. Cows on the high feeding regime had a mean daily weight gain of 75 g whereas those on the low and medium regimes lost 8 and 54 g respectively. The milk trend for 35 weeks of lactation is shown graphically in Figures 1a, b and c and the concentrate intake on a weekly basis is shown in Figure 1d. The results were in agreement with the findings of Aronorich *et al.* (1966) cited by Jeffrey (1971). Catchpoole and Henzell (1971) concluded that milk production from tropical forages will be satisfactory only when the level of supplementary feed in the diet is high.

Table 8. The effect of roughage alone (R), roughage plus urea, roughage plus urea molasses solution (UMS), roughage plus urea molasses cake (UMC),and roughage plus calf concentrate (CC) on the weight gain in 112 days (kg), dry matter feed intake (kg animal^{-1} day^{-1}), mean daily weight gain (g) and weight gain (g) per 100 TSh invested in concentrate, of young Fresian heifers

	R	R+urea	R+UMS	R+UMC	R+CC
Mean initial weight	91.2	89.7	91.0	92.1	91.3
Weight gain in 112 days	3.0	4.3	13.3	35.7	53.5
Roughage dry matter intake	1.9^{c}	2.0^{c}	2.2^{b}	2.5^{a}	1.9^{c}
Mean daily weight gain	27.0^{d}	38.0^{d}	119.0^{c}	319.0^{b}	478.0^{a}
Weight gain for every 100 TSh invested	-	446.0	661.0	159.0	149.0

$^{a, b, c, d}$Within a row, values assigned different letters differ significantly (P<0.05).
Source: UAC, 1986.

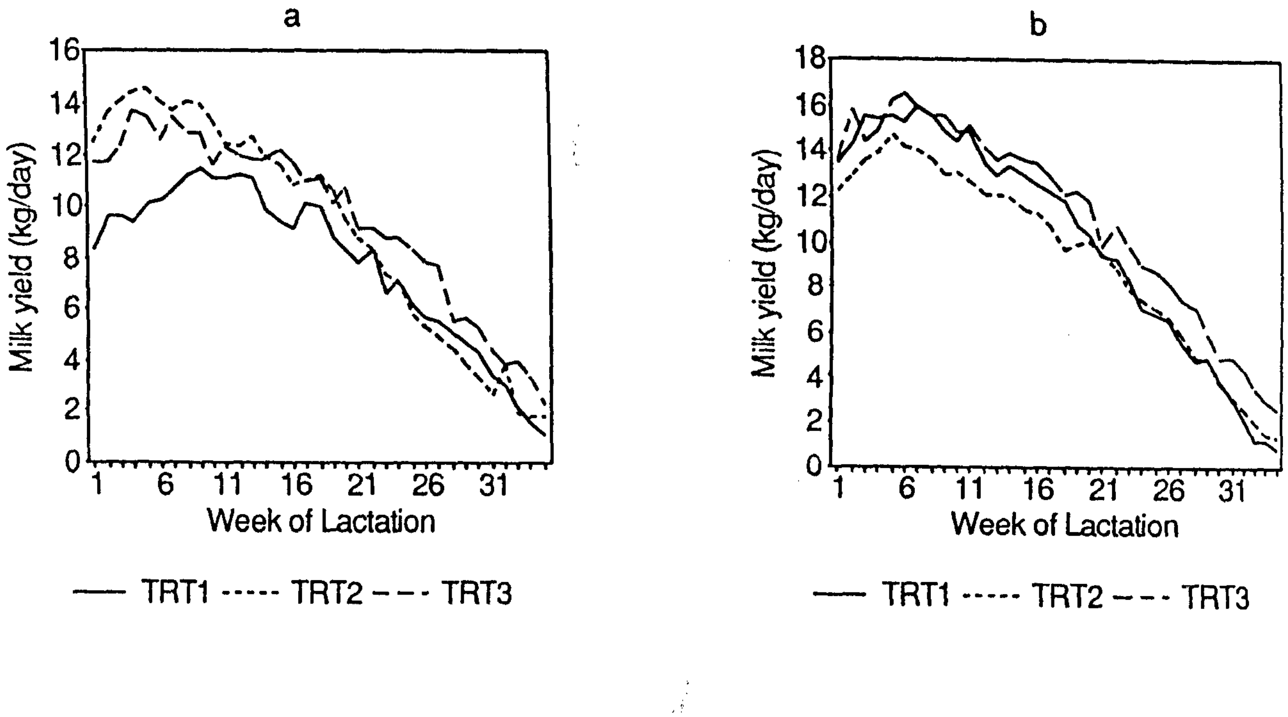

Figure 1. Mean milk production for cows under three different feeding regimes, during a) first lactation and b) second lactation

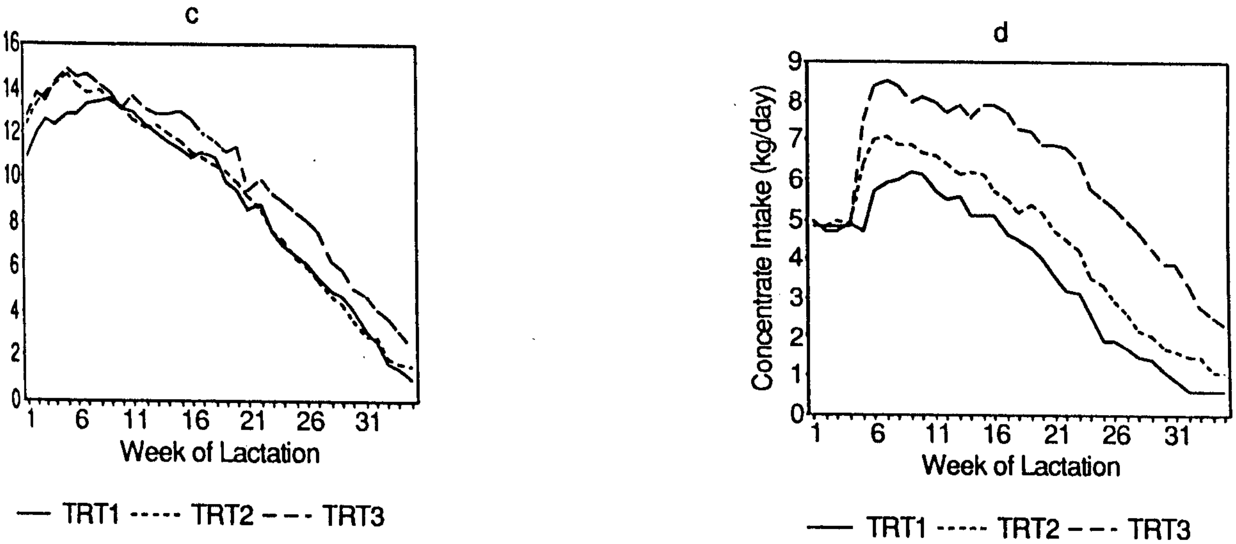

Figure 1. Mean milk production for cows under three different feeding regimes, during c) first and second lactation combined, and d) mean concentrate intake during first and second lactations

Studies on the content of major minerals in pastures are limited in Tanzania. Unpublished reports (Maro, 1982, 1983, 1990) indicate that most pastures in the Southern Highlands have a phosphorus content of less than 0.2%, which is inadequate to meet animal requirements, and soil analyses and fertilizer response trials (Johnsson and Rombulow-Pierce, 1976) have shown that phosphorus is the main factor crop limiting yields in the region. Elsewhere, Falvery (1985) has shown that in mineral deficient areas, sodium supplementation results in a more significant response than any other supplement, including energy, protein and phosphorus.

Of the trace elements, copper is commonly deficient in the Southern Highlands. Kamasho and Singh (1982) found that over 80% of the areas they surveyed were deficient in copper, confirming earlier observations by Johnsson and Rombulow-Pierce (1976). Feeding trials have shown a significant response in terms of growth rate and serum copper levels in growing dairy calves given a supplement containing copper (Maro *et al.*, 1979). The authors also reported high levels of molybdenum in the serum, which could have exacerbated the copper deficiency.

Iodine deficiency has been reported in various parts of the country, especially in Iringa, Kilimanjaro, Mbeya and Ruvuma Regions (Anon., 1978). Weavers (1969) and Kategile and Mgongo (1978) found that iodine supplementation improved reproductive performance in sheep and goats, as well as reducing the incidence of goitre.

Naik (1965) reported a deficiency of cobalt in the northern parts of Tanzania. Results for the Southern Highlands showed cobalt deficiency symptoms were the first to develop when mineral supplementation was withheld from sheep in the Iringa Region (Weavers, 1969). A dramatic improvement in live-weight gain was observed when a cobalt supplement was given.

ACHIEVEMENTS AND CONSTRAINTS

On most smallholder farms in the Southern Highlands, cattle production is only one of several integrated farm activities. An exception is the case of pastoral livestock keepers who, together with the agro-pastoralists, mainly rear the traditional zebu cattle. The settled agriculturalists, who live in areas with a relatively high population density and for whom the cultivation of food and cash crops has traditionally been the most important agricultural activity, are the most receptive to innovations in small scale dairy production. Many of these farmers now rank livestock keeping as second to food crop production in economic importance. The animals in this smallholder improved-cattle production system are either grazed during the day and stall-fed at night or entirely stall-fed. Supplements, especially of energy feed, are usually provided. The need for improved pastures is appreciated; for example, from 1985 to 1991, about 833 ha of improved pastures were established in Iringa and Mbeya Regions by farmers under the Small-scale Dairy Development Project (SSDDP, 1991).

Despite these achievements, the potential of the small scale dairy farming system is yet to be fully exploited because of the following constraints:

- *Availability and quality of feeds.* Feed supplies fluctuate as a result of seasonal variations but, to-date, conservation of surplus forage from the rainy season is minimal. The technology to improve poor quality roughage and supplementary feeds are not usually available to the farmer.

- *Animal diseases.* Diseases still form a major constraint, especially those that are tick-borne. Most government-run dips are not in operation. Although some farmers hand spray, the high price of acaricides and their unskilled application are important limiting factors.

- *Genetic resource.* Although the demand for improved cattle is high, production is limited, and few farmers are able or willing to pay the high prices demanded.

- *Marketing system.* The marketing and transport system is still poorly developed, especially in rural areas, and in many areas surplus milk is becoming a problem. Most farmers supply fermented milk.

- *Input supply.* Compared with the case in crop production, the delivery of inputs to livestock farmers is not well developed. For example, there is no institution involved in the commercial production of pasture seed. A major limiting factor is the price of inputs, especially veterinary drugs and mineral supplements.

- *Livestock extension services.* Our experience shows that the extension services rendered to livestock farmers are mainly limited to treatments. Education on feeding regimes and husbandry practices is minimal.

- *Recurrent expenditure.* Insufficient recurrent expenditure on government livestock services is probably one of the most serious constraints, and has led to a considerable deterioration in animal health services. For example, it is probable that fewer than 20% of all the dips in the country are functioning.

INNOVATIONS FOR INCREASING PRODUCTION

Although the development of a complete technological package of recommendations for improving production on smallholder farms is important, farmers rarely adopt all the recommendations at once for a number of reasons. Among these are the demand for labour for other activities and limited capital. The following list is therefore an attempt to prioritize the introduction of innovations, as a guide to both extension and research work.

- *Improvement of genetic resources.* The local zebu is not a good dairy cow, even under good management. Its milk production potential is less than 900 kg per lactation. The use of crossbred animals, with an average milk production of more than 2000 kg per lactation, will considerably improve production.

- *Use of good quality forage.* Given an improved crossbred animal, the next step is the provision of good quality forage by the establishment of improved pasture and the harvesting and storage of hay and crop residues.

- *Energy and protein supplementation.* High energy feeds, such as maize bran and rice polishings, should be used, together with protein feeds, such as cotton seed cake, to supplement the traditional forages.

- *Mineral supplementation.* Supplementation with inorganic nutrients will further improve the condition and productivity of cattle. In practice, calcium, sodium, phosphorus, sulphur, magnesium and the trace elements, cobalt, copper, selenium, zinc and iodine, are the minerals most likely to be in short supply.

- *Control of parasites.* Though mortality rates due to helminthic infection can sometimes be high, insidious losses of productivity through reduced feed intake and decreased efficiency of utilization of feed are very often the largest economic losses.

- *Use of purebred cattle.* After a farmer has gained experience in improved animal husbandry, the next step is to increase milk production further by the use of animals with greater genetic potential.

- *Provision of shelter and adequate water.* In cattle, a large amount of heat is produced by fermentative digestion and by metabolism, especially on diets high in fibre. Feeding the animals under cool environments can help make conditions more comfortable for highly productive cows. Water is essential for cattle production. Water requirements are related to heat load, growth and milk production.

- *Forage conservation and treatment of low quality roughages.* Under the conditions in the Southern Highlands, it is difficult to provide good quality forage year-round. Farmers need to make silage and hay, and also to improve their crop residues by chemical treatment.

- *Use of proven sires.* Maintenance of high productivity in the medium term depends on a good breeding plan. Artificial insemination would help ensure the use of good genetic material.

FUTURE RESEARCH PRIORITIES

Two main categories of research priorities are considered here: on-station research, to evaluate feed resources by feeding trials, and on-farm research to take account of social-economic constraints. The aim is to develop technology packages that will be readily accepted and adopted by smallholder farmers.

- *Improvement of low quality roughages.* Improvement of the feeding values of crop residues and standing hay is of paramount importance. Methods for the treatment of residues are available but have not yet been introduced to the farmers.

- *Simple methods of hay making.* Forage harvesters and bailers are used on government farms. There is an urgent need to develop methods appropriate for smallholders.

- *Evaluation of feed supplements.* There is a need for low cost feed supplements which can be produced on the farm. Evaluation of new and unusual sources of supplements, such as the foliage of leguminous and non-leguminous trees and shrubs, which have considerable potential as on-farm sources of nutrients, should be carried out.

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