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The Production, Storage and Feeding of Herbaceous Forages to Support Ruminant Livestock in Developing Countries of the Tropics and Subtropics

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THE PRODUCTION, STORAGE AND FEEDING OF HERBACEOUS FORAGES TO SUPPORT RUMINANT LIVESTOCK IN DEVELOPING COUNTRIES OF THE TROPICS AND SUBTROPICS

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PREFACE

There is urgent need in developing countries to substantially increase livestock production to supply meats and milk products to the National Markets and to exploit the underdeveloped potential for animal power in agricultural development. These aspects of livestock enterprises based on ruminants (cattle, buffalo, goats and sheep) must be supported primarily by forages produced as by-products of crop production on arable lands, and by feeds from permanent grazing lands. The use of grains for livestock enterprises is unrealistic in developing countries, because of the priority use of all available grains and seeds to meet human food needs.

This report provides essential information on the comprehensive support of ruminant livestock on agricultural lands, that should substantially improve farm incomes, as well as contribute to indigenous food supplies for total populations.

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THE PRODUCTION, STORAGE AND FEEDING OF (HERBACEOUS) FORAGES TO SUPPORT RUMINANT LIVESTOCK IN DEVELOPING COUNTRIES OF THE TROPICS AND SUBTROPICS

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THE PRODUCTION, STORAGE AND UTILIZATION OF HERBACEOUS FORAGES FOR SUPPORT OF RUMINANT LIVESTOCK IN DEVELOPING COUNTRIES OF THE TROPICS AND SUBTROPICS

Howard B. Sprague

Introduction

Animal agriculture in developing countries of the tropics and subtropics offers important opportunities for greater productivity. There has been much less research and development of animal agriculture than has been applied to crop production, but there may be comparable potential benefits. In addition to direct benefits from efforts directed to the productivity of ruminant livestock, the interaction of soil improvement through nutritious forages grown for feed in rotations on arable soils has important long-term agricultural benefits. Further, the effective conservation and utilization of animal manures applied to crops is an important beneficial practice.

Ruminant livestock (cattle, buffaloes, goats and sheep) are the indigenous source of meats, and of milk and milk products, that are highly essential foodstuffs for human diets; a these may be produced by animals supported largely or wholly by herbaceous forages. Such forages include grasses and legumes grown on rangelands and seeded pastures, as well as crop by-products and crop residues from crop lands (stalks, vines, straw, and unmarketable crop products). Unlike the developed countries of the western world where grains, seeds, and other concentrates are important livestock feeds, the developing nations must channel such concentrates to human foods for support of burgeoning national populations. However, local production of herbaceous forages as the principal feedstuffs for ruminants substantially broadens the scope of modern agriculture in the tropics and subtropics.

Also, animal power from cattle (oxen) and buffaloes should greatly reduce the amount of human labor in agriculture of the tropics and subtropics per unit of crop produced. Since the work animals may be grown on the local lands, and be completely supported by herbaceous feedstuffs, the average small farmer may meet much of his power needs without recourse to costly petroleum powered machinery and vehicles.

Note should be made also of the contributions of livestock in the form of hides and skins, and the wool and hair that are economically important commodities.

This publication deals with the production and utilization of herbaceous forages for support of ruminant livestock as a vital component of modernized productive agriculture.

I. The Current Status of National Deficiencies in Supplies of Meats and Meat Animals and of Dairy Products

The imports of animal foodstuffs is an index of market demands that are not satisfied by domestic production. The import data are provided by the yearly trade yearbook of the Food and Agriculture Organization (FAO) of the U.N. A sample of such data for 14 representative countries is presented in Table 1. These data are not adjusted for the size of national populations, but they indicate very large imports of animal foodstuff that constitute serious commitments of national foreign exchange earnings. Dairy products are more universally imported than meats and meat animals. These data are not unique for 1980; similar imports have been reported for previous years. It seems clear that domestic production of animal foodstuffs has not kept pace with market demands. These demands are largely those of urban centers, since rural areas either subsist on local production, or substitute other foodstuffs for animal products.

Table 1 also shows the percentage of total national populations engaged in agriculture; and the national index of per capita food production in 1980 as a percent of production in 1970, for these 14 representative countries. There is no visible correlation between the percentage of population engaged in agriculture and the imports of animal foodstuffs. While the general status of per capita food production has made gains in some countries, these appear to be unrelated to imports of animal foodstuffs. National food status may be substantially improved by greater efficiency in producing meats and dairy products.

Table 1. Imports[1] of Animal Foodstuffs in Representative Developing Countries in 1980 (FAO data)

County	Meats and Meat animals ($000)	Dairy Products ($000)	Percent of total Pop. engaged in Agriculture %	Index values of total food production per capita (2) 1970	1980
AFRICA					
Liberia	$19,751	5,506	69.7%	100%	97%
Sierra Leone	16,520	8,500	65.1%	100%	89%
Kenya	776	14,256	77.6%	100%	85%
Tanzania	0	11,570	81.0%	100%	89%
Ghana	23,875	10,295	50.8%	100%	82%
North Africa & Middle East					
Morocco	14,866	69,602	51.2%	100%	86%
Pakistan	3	38,663	53.5%	100%	101%
Syria	23,350	114,300	47.5%	100%	167%
Far East					
Philippines	13,186	111,040	46.0%	100%	114%
Indonesia	6,585	74,834	58.9%	100%	122%
Thailand	2,599	74,250	75.4%	100%	125%
Latin America & Caribbean					
Dominican Republic	9,768	8,269	56.1%	100%	96%
Guatemala	46,657	7,540	54.9%	100%	114%
Jamaica	26,168	21,480	20.7%	100%	96%
Peru	24,320	61,890	37.3%	100%	77%

Footnotes:

(1) The imports constitute market demands not satisfied by domestic production. (Mostly supplying urban markets)

(2) Per capita total food production for the base period of 1969-71, was generally judged to be seriously deficient in developing countries. The 1980 satus indicates changes from the base period.

II. Rural Populations and Their Ruminant Livestock

Agricultural populations are reported by FAO as total numbers, as well as that portion that is "economically active." The economically active portion may be assumed to include working adults (men and women) who are contributing to total productivity. These economically active persons are actually the key components of family units. It is important to evaluate agricultural operations in terms of family units, since these also are the decision-making entities for agricultural operations. These family units decide on the extent and nature of livestock enterprises that are maintained. In Table 2, the estimated number of family units is obtained by assuming an average of 6 economically active persons per family unit.

Table 2 shows the number of family units in each of 45 representative developing countries, and the associated number of animal units per human family unit. These ruminant animal units include cattle, buffaloes, goats and sheep. It is assumed that 1 cow or 1 buffalo = 1 animal unit. Because of smaller sizes, it is assumed that 5 goats or 5 sheep = 1 animal unit. These numbers are shown in appendix Table B.

There is a wide range of animal units per agricultural family in the 45 representative developing countries, reported in Table 2. These wide differences are caused by the differing amounts of grazing lands in relation to arable lands, the population pressure on meat animals and meats, and the traditional types of agriculture in the respective countries. As will be shown later in this report, livestock production may be substantially increased. Opportunities for improvement are apparent; and this paper outlines the feed potentials to support such improvements.

Table 2. Human Population in Representative Developing Countries and their ruminant livestock (1980 FAO data)

	Total Human Population (000)	Population engaged in Agriculture (000)	Percent of Population engaged in Agriculture %	Estimated number of agricultural Family units (000)*	Total annual units per per family (**)
Africa					
Botswana	821	658	80.2	51	71
Cameroon	8,444	6,815	80.7	527	7
Ghana	11,679	5,988	50.6	366	5
Kenya	16,402	12,723	77.6	802	16
Liberia	1,863	1,299	69.7	79	1
Malawi	6,162	5,159	83.7	383	3
Mali	6,646	5,779	87.0	517	14
Niger	5,305	4,662	87.9	241	23
Senegal	5,661	4,211	74.4	290	12
Sudan	18,371	14,120	76.9	729	39
Swaziland	556	403	72.6	31	23
Tanzania	17,934	14,532	81.0	988	17
Togo	2,699	1,837	67.9	125	5
Upper Volta	6,908	5,622	81.4	498	7
Zaire	28,291	21,008	74.3	1,476	1
Zimbabwe	7,396	4,339	58.7	237	29
North Africa and Near East					
Egypt	41,995	21,261	50.4	1,000	5
Jordan	3,190	811	25.8	33	9
Lebanon	3,161	312	9.9	14	17
Morocco	10,296	10,381	51.2	456	17
Syria	8,644	4,106	47.5	175	14
Tunisia	6,363	2,502	40.6	103	22
Yemen	5,926	4,442	75.0	209	17
Asia					
Bangladesh	88,705	74,335	83.8	4,219	8
Burma	35,289	18,276	51.8	1,216	8
Indonesia	151,894	89,398	58.9	5,090	2
Nepal	14,256	13,198	92.6	1,044	11
Pakistan	82,441	44,113	53.5	1,989	19
Philippines	50,996	23,344	46.0	1,350	4
Sri Lanka	14,871	7,913	53.2	459	6
Thailand	47,674	35,927	75.4	2,681	4
Latin America & Caribbean					
Bolivia	5,572	2,785	50.0	151	42
Costa Rica	2,213	776	35.1	43	48
Dominican Republic	5,946	3,335	56.1	146	15
Ecuador	8,023	3,566	44.5	189	16
El Salvador	4,801	2,467	50.4	126	11
Guatemala	7,262	3,985	54.9	202	8
Guyana	884	192	21.7	11	29
Haiti	5,817	3,876	66.6	323	4
Honduras	3,693	2,311	62.6	113	16
Jamaica	1,192	454	20.4	26	14
Nicaragua	2,737	1,143	42.8	58	49
Panama	1,944	670	34.5	37	38
Paraguay	3,067	1,499	48.9	80	66
Peru	17,773	7,035	37.3	326	23

* Family unit in agriculture estimates based on 6 adults per family unit, of that portion of rural population economically active in agriculture. FAO data 1980. See Appendix Table A

** See Appendix Table B for numbers of each type of ruminant.

III. Land Use for Agricultural Activities

It is obvious that forage production for livestock is dependent on the lands that are available; but the potential for conserving forages on arable crop land has received little attention. A close evaluation of this potential reveals forage production as by-products of cropping is quite substantial, and provides useful supplements to perennial grazing lands in providing year-round forage. Also, forage components of crop rotations should be a major factor in soil improvement of arable lands.

The basic data on present agricultural land uses are reported in Table 3, for 45 representative developing countries. In addition to the total hectares of arable lands, and of permanent grazing lands, the table provides estimates of these lands that are available per family unit. Some thinly populated countries (such as Botswana, Sudan, Syria, Tunisia, Bolivia, Guyana and Nicaragua) have larger areas of arable land per family unit. In some of these countries, which have subhumid climates, certain lands are arable but have lower crop yields due to limited rainfall. In a few countries with traditionally large land holdings, this type of ownership dominates.

For the countries with large areas of permanent grazing land per family unit, this is largely caused by expanses of semi-arid lands unsuited for cropping, but which produce forage that can be utilized by grazing with ruminant livestock. The countries with large areas of semi-arid or subhumid grazing lands have relatively large herds and flocks of ruminant livestock. The developmental goals of such countries should plan for increased forage production as the basis for greater livestock productivity.

Table 3. Land Use in Representative Developing Countries (FAO 1980 data)

	Total Hectares of arable lands (000)	Total Hectares Permanent Grazing lands (000)	Total Agricultural Family Unit* (000)	Average Arable land per agricultural Family Unit (Hectares)	Average Grazing per Fami (Hectare:
Africa					
Botswana	1,360	44,000	51	26.7	863
Cameroon	5,998	8,300	527	11.2	16
Ghana	1,090	3,480	366	3.0	9
Kenya	1,790	3,770	802	2.2	5
Liberia	245	240	79	3.1	3
Malawi	2,280	1,840	383	5.6	5
Mali	2,047	30,000	517	4.0	58
Niger	3,290	9,668	241	13.7	40
Senegal	5,195	5,700	290	17.9	20
Sudan	12,345	56,000	729	16.9	77
Swaziland	150	1,250	31	4.8	40
Tanzania	4,110	35,000	988	4.2	35
Togo	1,355	200	125	10.8	0.2
Upper Volta	2,550	10,000	498	5.1	20
Zaire	5,707	9,221	1,476	3.9	6
Zimbabwe	2,465	4,856	237	10.4	20
North Africa & Near East					
Egypt	2,700	0	1,000	2.7	0
Jordan	1,180	100	33	35.8	3
Lebanon	240	10	14	17.1	0.7
Morocco	7,269	12,500	456	15.9	27
Syria	5,230	8,274	175	29.9	47
Tunisia	3,450	2,550	103	33.5	25
Yemen	2,740	7,000	205	13.4	34
Asia					
Bangladesh	8,918	600	4,219	2.1	0.1
Burma	9,579	361	1,216	7.9	0.3
Indonesia	14,168	12,000	5,090	2.8	2
Nepal	2,305	1,700	1,044	2.2	2
Pakistan	19,900	5,000	1,989	10.0	2.5
Philippines	7,050	1,000	1,350	5.2	0.7
Sri Lanka	1,019	439	459	2.2	1
Thailand	16,250	308	2,681	6.1	0.1
Latin America & Caribbean					
Bolivia	3,250	27,100	151	21.5	179
Costa Rica	283	1,358	43	6.6	32
Dominican Republic	880	1,500	146	6.0	10
Ecuador	1,750	2,560	189	9.3	14
El Salvador	530	610	126	4.2	5
Guatemala	1,460	880	202	7.2	4
Guyana	364	999	11	33.1	91
Haiti	545	510	323	1.7	1.6
Honduras	1,560	3,400	113	13.8	30
Jamaica	205	210	26	7.9	8
Nicaragua	1,335	3,400	58	23.0	59
Panama	455	1,161	37	12.3	31
Paraguay	1,202	15,200	80	12.8	19
Peru	3,100	27,120	326	9.5	83

* See Appendix Table A for explanation of family units.

IV. The Estimated Potential for Forage Production on Agricultural Lands of Developing Countries

Ruminant livestock operations are most likely to be successful, where forage supplies are adequate for year-round support of the livestock. The following sections provide estimates that are extensions of limited field trials, but are believed to be quite feasible under the physical environments of developing countries. These will include: (a) crop by-products and residues from crops grown on arable lands; (b) single-season soil improving crops included in crop rotations that provide forage; (c) seeded perennial pastures and forages grown in long-term rotations, or on Capability Class IV lands that are too sloping or erosive for sustained cropping; and (d) the permanent grazing lands of semi-arid range lands, or those lands that are non-arable because of stoniness, shallow depth, rugged terrain, etc.

Estimated forage by-products and residues of crop production on arable lands; that may provide support for ruminant livestock:

1. For humid regions of the tropics (see report by Tillman, p. 37): Yearly rainfall over 2,000 mm. with "dry season of 2 months or less.

		Dry Matter Yields of Forage per 10 Hectares
a.	2 Hectares of straw of cereal grains (rice, wheat, barley)	5,000 kg
b.	4 Hectares of stalks and green leaves--after grain harvest (maize, sorghum, millet)	15,000 kg
c.	2 Hectares of tops of food grain crops (groundnuts, beans, cowpeas, mung beans, etc.)	5,000 kg

d.	1 Hectare of tops of sweet potatoe vines, cassava tops, etc.	1,500 kg
e.	1 Hectare of unmarketable crops (vegetables, root crops, volunteer forage on roadside, unplanted lands)	1,500 kg
	Total	28,000 kg per 10 Hectares

2. For wet-dry tropics and subtropics:

Estimated forage production, as by-products of cropping on 10 hectares of arable lands:

Yearly rainfall - 1,000 to 2,000 mm.

Dry season - 3 to 5 months

Forage production potential on 10 hectares, one-half of humid region = 14,000 kg/year dry matter.

3. For subhumid tropics and subtropics:

Estimated forage production, as by-products of cropping on 10 hectares of arable lands:

Yearly rainfall - 500 to 1,000 mm.

Dry season - 5 to 7 months

Forage production potential on 10 hectares, one-third of humid region = 9,000 kg/year dry matter.

4. For semi-arid regions:

Estimated forage production, as by-products of cropping on 10 hectares of arable lands:

Yearly rainfall - 250 to 500 mm.

Dry season - 7 to 10 months

Forage production potential on 10 hectares, one-fifth of humid region = 5,000 kg/year dry matter.

For all regions, it is assumed that effective crop cultural practices will be applied, including improved crop varieties, appropriate use of fertilizers and soil amendments to alleviate soil fertility deficiencies; and that prompt harvest of the forages, their effective storage, and practice of sound methods of feeding to livestock, will prevail. These aspects will be discussed in subsequent sections.

V. Meeting Feed Intake Requirements for Ruminant Livestock

The following values may serve as guidelines.

Average feed requirements per animal unit[1]

	Dry Matter per Year
1. For animal maintenance only: oxen, mature cattle, or buffaloes	
a. Per large animal unit	2,000 kg
b. Per 5 goats, or 5 sheep (= 1 A.U.)	2,000 kg
(Dry matter of feeds assumed to be 50% readily digestible and averaging 5 to 6% crude protein.)	
2. Total feed requirement for lactating females:	
a. Per milking large ruminant	2,700 kg (= 8.0 kg/day per animal)
b. Per milking goat or sheep	540 kg (= 1.6 kg/day per animal)
3. Total feed requirement for young stock:	
a. Large ruminants, per animal	1,600 kg (= 4.0 kg/day)
b. Small ruminants, per 5 animals	1,600 kg (= 320 kg/yr per sheep or or per goat; or 1.0 kg/day)

[1]Animal Units (A.U.): 1 mature bovine animal = 1 A.U.
5 goats or sheep = 1 A.U.

NOTE: Since much of the dry forage produced as a by-product or residue of crops is generally low in protein content, all lactating animals, and all growing young stock should receive a forage protein supplement to support milk flow for females and for growth of young stock.

VI. Supplemental Protein Forages for Milk Producing Animals (cows, buffaloes, goats, sheep), and for Young Growing Livestock

For all milk-producing animals, supplemental feeding of forage protein supplement should begin 1 month before calving for large ruminants, and 2 to 3 weeks before lambing or kidding. Such feeding should continue as long as there is milk flow. The amount of indigenous forage protein supplement will vary with the type of such feeds, as follows:

1.	Green leguminous forages	Fresh plant weight (4 kg fresh weight = 1 kg dry matter)
	a. Per cow or buffalo	7.0 kg/day
	b. Per goat or sheep	1.4 kg/day
2.	Dry leguminous forages (hay)	Dry weight
	a. Per cow or buffalo	2.0 kg/day
	b. Per goat or sheep	0.4 kg/day
3.	Mixed grass/legume (green)	Fresh green weight
	a. Per cow or buffalo	14.0 kg/day
	b. Per goat or sheep	3.0 kg/day
4.	Mixed grass/legume (hay)	Dry weight
	a. Per cow or buffalo	4.0 kg/day
	b. Per goat or sheep	1.5 kg/day
5.	Oilseed cake or meal (where necessary)	Dry weight
	a. Per cow or buffalo	1.5 kg/day
	b. Per goat or sheep	0.3 kg/day

Feeding Milking Animals

It is important to give high priority to meeting feed requirements for all milking animals, since deficient feed intake will promptly curtail milk flow, or cause lactation to cease entirely. There must be a continuing supply of water, as well as feed, to maintain milk flow. These two requirements are not generally recognized, and cause low and uncertain milk production. Meeting feed requirements of indigenous milking animals is generally far more important than costly importation of exotic milk breeds of livestock.

The period of feeding protein supplements to goats and sheep should be adjusted to the lactation periods of these small ruminants, which may average 3 to 4 months per animal under the management systems practiced in developing countries. However, individual females that lactate for longer periods should receive protein feed supplements throughout the lactation period.

Feeding Young Growing Stock

Young growing stock, after weaning, also are dependent on adequate feed supplies and regular watering; but feed deficiencies of short duration can be accepted, if followed by periods of abundant feeds. This tolerance is not present in milking females; and milk flow usually is permanently depressed when caused by even short-term feed shortage or water deficits.

VII. Potential Livestock Feed Support from Crop By-products Available on 10 Hectares of Arable Crop Land

It is assumed the crop by-products and residues will be harvested promptly, stored, and rationed to livestock over the entire year. The potential feed support is reported separately for each climatological region.

A. For the humid tropics: 10 hectares of arable crop land

Total crop by-products and residues = 28,000 kg/yr of dry weight.

Proposed utilization:

	Dry weight
1. Four work animals (4 A.U.*)	
a. Maintenance ration	8,000 kg/yr
b. Forage protein supplement	3,000 kg/yr
Subtotal	11,000 kg/yr
2. Four milk animals--cows, buffaloes (or 5 milk goats or sheep per large ruminant) (4 A.U.)	
a. Maintenance ration	8,000 kg/yr
b. Forage protein supplement	3,000 kg/yr
Subtotal	11,000 kg/yr
3. Four young bovines--after weaning (or 20 young lambs or kids with equivalent feed requirements) (2 A.U., ½ full ration each)	
a. Maintenance ration	4,000 kg/yr
b. Forage protein supplement	1,400 kg/yr
Subtotal	5,400 kg/yr
Humid Tropics: Grand Total	27,400 kg/yr

*A.U. = Animal Unit = 1 large ruminant (cattle or buffaloes)
= 5 goats or 5 sheep

B. For the wet-dry tropics

Total forage crop by-products and residues = 14,000 kg/yr on 10 hectares of crop land (= ½ the level of humid region). Proposed utilization:

		Dry weight
1.	Two oxen (2 A.U.)	
	a. Maintenance ration	4,000 kg/yr
	b. Forage protein supplement	1,500 kg/yr
	Subtotal	5,500 kg/yr
2.	Two milk cows or buffaloes (or 10 milk goats or sheep) (2 A.U.	
	a. Maintenance ration	4,000 kg/yr
	b. Forage protein supplement	1,500 kg/yr
	Subtotal	5,500 kg/yr
3.	Ten growing lambs or kids	
	a. Maintenance ration	2,000 kg/yr
	b. Forage protein supplement	750 kg/yr
	Subtotal	2,750 kg/yr
	Wet-Dry Tropics: Grand Total	13,750 kg/yr

C. For the subhumid and Mediterranean region

By-product forages produced on 10 hectares of crop land = 9,000 kg/yr (= 1/3 of the level for humid regions). Proposed utilization:

	Dry weight
1. One ox (1 A.U.)	
a. Maintenance ration	2,000 kg/yr
b. Forage protein supplement	750 kg/yr
Subtotal	2,750 kg/yr
2. One milk cow or buffalo, plus 3 milk goats or sheep	
a. Maintenance ration	3,200 kg/yr
b. Forage protein supplement	1,000 kg/yr
Subtotal	4,200 kg/yr
3. Growing young stock (calves, kids, lambs)	
a. Maintenance ration	1,550 kg/yr
b. Forage protein supplement	500 kg/yr
Subtotal	2,050 kg/yr
Subhumid & Mediterranean Region: Grand Total	9,000 kg/yr

D. For semi-arid regions

Forages produced on 10 hectares of cropland as crop by-products and residues = 5,000 kg/yr (as 1/5 the level of the humid regions). Proposed utilization of forages:

	Dry weight
1. One work animal (1 A.U.)	
a. Maintenance ration	2,000 kg/yr
b. Forage protein supplement	750 kg/yr
Subtotal	2,750 kg/yr

		Dry weight
2.	Three milk goats (or sheep)	
	a. Maintenance ration	1,200 kg/yr
	b. Forage protein supplement	400 kg/yr
	Subtotal	1,600 kg/yr
3.	Young kids or lambs	
	a. Maintenance ration	500 kg/yr
	b. Forage protein supplement	125 kg/yr
	Subtotal	625 kg/yr
	Semi-arid region: Grand Total	4,975 kg/yr

NOTE: There is a strong tendency for arable crop land per family unit to be larger in regions of limited rainfall. The arable cropland is approximately adjusted upward to the amount necessary to support the family unit. Although the foregoing estimates are based on 10 hectares of cropland for each region, the potential livestock support from crop by-products may be adjusted to the actual arable crop land per family unit in any specific area.

VIII. Annual Soil Improving Crops on Arable Lands as A Feed Source*

Such annual crops are important for improving soil structure, for rainfall conservation, for adding nitrogen through fixation by leguminous forages, and for improving productivity of subsequent crop plants. The forages produced on lands thus treated are prime sources of feedstuffs for ruminant livestock. The major soil improving crops for different regions are as follows:

A. For the tropics in humid regions, and in wet-dry tropics:

A mixture of sudan grass and a vining type of cowpeas. When planted at the start of the season of rains, there should be at least two cuttings of forage; the first harvest may be made after 8 to 10 weeks of growth, with rapid regeneration from the stubble to produce a second harvest in about 8 weeks. The total yield should amount to 2 to 4 metric tons of hay per hectare. (On a freshly harvested green basis, this would amount to 8 to 12 metric tons of fresh forage. About 4 metric tons fresh weight equals 1 metric ton of dry weight.)

B. For the region of Mediterranean climate, with rainfall in the cool season, there are two choices:

1. Ryegrass and vetch mixture
2. Canary grass and vetchling (grass pea) mixture.

Forage yields may range from 1 to 2 tons per hectare of total dry weight (hay) in a single crop harvest.

Where such forage mixtures are at least 50% made up of the legume component, this feed may serve as the protein supplement for livestock rations.

*For more detailed information, see publication "The Status and Challenge of Dryland Agriculture in Developing Countires of the Tropics and Subtropics," pp. 81-84; published by U.S. Agency for International Development, Bureau for Program and Policy Coordination; 1981.

Figure 1. Pearl Millet ready for grain harvest. With millet, sorghum and maize, the grain should be harvested as soon as ripe, so that green stalks and leaves may be cut and stored for feeding ruminants whenever needed. Such forage is particularly valuable for feeding in dry seasons.

Figure 2. A pigeon pea crop ready for seed harvest. The vines and green leaves should be harvested and stored immediately after seed harvest, to provide feed for ruminant livestock. Such vines and green leaves of all other food grain legumes, as well as pigeon peas, are high in protein and provide highly nutritious feeds to balance forages from other crops and non-leguminous plants. Other food grain legumes include all types of beans, peas, groundnuts, chickpeas, etc.

IX. Seeded Perennial Forage Legumes* as A Source of Forage Protein Feed Supplements

A. Such seeded forage plantings may be useful on lands with such limitations as stoniness, susceptible to water erosion, shallow soil depth, or other characteristics that make regular tillage unprofitable. There is a wide range of different perennial species of forage legumes and of forage grasses, that may be selected for different climatic zones. Suggested choices are listed in the following section. Further details on soil adaptation of each species, its characteristics, and culture and utilization are covered in S&T/AGR Technical Bulletin 14.*

The general aspects of establishing seeded pastures, and their management for support of livestock are discussed in S&T/AGR Technical Bulletin 13. It is particularly important to select species that are adapted to local soil conditions, as well as to the climatic conditions.

*S&T/AGR Technical Bulletin No. 14, Characteristics of Economically Important Food and Forage legumes and Forage Grasses for the Tropics and Subtropics.

Also: S&T/AGR Technical Bulletin No. 13, Seeded Forages for Grazing and Harvested Feeds in the Tropics and Subtropics; and special publication: A Legume-Based Pasture Production Strategy for Acid Infertile Soils of Tropical America, by S&T/AGR, U.S. Agency for International Development, Washington, D. C.

B. Suggested perennial species of forage legumes and grasses for use in seeded pastures:

1. Species for the humid tropical regions

Forage Legumes	Forage Grasses
Calopo (Calopogonium mucunoides)	Angelton grass (Dicanthium aristatum)
Centro (Centrosema pubescens)	Bahia grass (Paspalum notatum)
Lablob (Dolichos lablab)	Bermuda grass (Cyndon dactylon)
Leucaena (Leucaena leucocephala)	Guinea grass (Panicum maximum)
Puero (Pueraoa phaseoloides)	Molasses grass (Melinis minutiflora)
Siratro (Macroptilium atropurpureum)	

2. Species for the wet-dry tropical regions

Centro (Centrosema pubescens)	Bermuda grass (Cyndon dactylon)
Greenleaf desmodium (Desmodium intortum)	Carib grass (Eriochloa polystachya)
Silverleaf desmodium (Desmodium uncinatum)	Guinea grass (Panicum maximum)
Leucaena (Leucaena leucocephala)	Molasses grass (Melinis minutiflora)
Siratro (Macroptilium atropurpureum)	Pigeon grass (Setaria sphacelata)
Stylosanthes (Stylosanthes guayensis)	Rhodes grass (Chloris gayana)
	Scroic grass (Paspalum commersonii)

3. Species for sub-humid tropics and subtropics

Glycine (Glycine wightii)	Blue panic grass (Panicum antidotole)
Lotononis(Lotononis bainesii)	Green panic grass (Panicum maximum tricoglume)
Phosey bean (Macroptilium lathyroides)	Harding grass (Phalaris tuberosa stenoptera)
Stylosanthes (Stylosanthes guayensis)	Makarikari grass (Panicum coloratum makarikariense)
	Plicatum grass (Paspalum plicatulum)
	Rhodes grass (Chloris gayana)

4. Species for the semi-arid tropics and subtropics

Dwarf Koa (Desmanthus virgatus)	Birdwood grass (Cenchrus setigerus)
Lucerne (Medicago sativa)	Buffel grass (Cenchrus ciliaris)
Townesville lucerne (Stylosanthes humilis)	Weeping love grass (Eragrostis curvula)
	Lehmann's love grass (Eragrostis lehmanniana)

C. Managing new seedings

When adapted species of legumes, or a legume-grass mixture of forage plants, is well established, it may be utilized by grazing, or harvested for hay to be fed in the dry season. This potential will permit utilizing larger numbers of ruminant livestock than would be supported by use of crop by-products and residues on arable crops. Intermittent or rotation grazing is generally the most rewarding in terms of fully utilizing the forage without damaging the length of life of the forage plantings. Unrestricted grazing in all seasons should be firmly prohibited, both for actual survival of the forage plants, and to insure that the forage yields fully reflect the soil and climate conditions.

When harvested as hay, the cuttings should be removed as soon as well wilted, to preserve the full nutritive value of the forage. This is particularly necessary for the legume forages, to avoid needless loss of leaves by shattering when dry and brittle. The leaves are far more nutritious to livestock than the stems.

The yields of forage (whether grazed or made into hay) will vary widely from pasture to pasture, in response to forage species, rainfall, soil fertility, and method of management and use. It is important that prior attention be given to the component forage legumes in providing feed from seeded pastures. The legumes are rich in protein content, and this nutrient compound is deficient in most other herbaceous feedstuffs. The grass component of mixed plantings is a useful contribution to yield, but is most valuable as a companion to the forage legume. When management practices succeed in fostering the legume, the benefits will extend to the grass component.

X. Rangelands as Suppliers of Feed for Ruminant Livestock

A. Extent: About two-thirds of the world's agricultural land is in the form of permanent native grazing land, that is unsuitable for crop production because of uncertain rainfall, unfavorable soil conditions, serious soil erosion, or other problems. These grazing areas are utilized successfully by ruminant livestock, thus augmenting crops produced on arable lands. Most of these permanent grazing lands may contribute to the welfare of rural families, and to the economy of the nation, only through the utilization by ruminant livestock. The actual hectares of these grazing lands is presented in Table 3, (p. 8) for 45 representative developing countries. This table also shows estimates as to the relation of such lands to the average family units of each country.

Most of the rangelands (permanent grazing lands) occur in regions with less than 1,000 mm. of yearly rainfall, with a dry season of 5 months or more. They are generally undeveloped, largely occupied by native plant species, and often heavily invaded by shrubs and other woody growth. Better methods of management to improve feed producing capacity are being developed for tropical and subtropical grazing lands.

B. The elements of effective rangeland management may be summarized as follows:

1. The stocking rate (number of animal units per unit of land area) must be adjusted to the total useable supply of forage on the range area. A mature cow (or 5 sheep or goats) should be provided with a minimum of 1,700 kg of dry forage per year. The stocking rate should assure that this standard will be met. This will be expressed as the hectares of range required to support each animal unit.

2. The yearly feed requirement may be partially satisfied by crop by-products on available arable land, or by seeded pastures. In any event, the number of grazing animal units dependent on rangeland production should not be exceeded if livestock are to be productive, and if the rangelands are to be protected from degradation.

3. All rangelands should be grazed in rotation during the growing season for forage plants, to permit regrowth and restoration of vegetative cover of the land.

4. Indiscriminate burning of rangelands during the dry season should be prohibited. Occasional controlled burning to reduce woody shrubs and scrub trees must be regulated by government range specialists.

5. Since undesirable woody growth tends to increase under any system of range management, hand grubbing of such harmful vegetation in the dry season will reduce undue competition for moisture and light that adversely affects growth of edible forage plants.

6. Introduction of superior forage legumes and grasses, adapted to the local region,, may be practiced wherever grubbing of shrubs and and other woody plants takes place. To be successful, seed of improved forage plants may be scattered on disturbed soil where grubbing has been done, when planted at the onset of the rainy season.

7. Efforts must be made to determine any mineral nutrient deficiencies in the forage consumed by livestock. The use of mineralized salt blocks is often practical. The minerals may include phosphorus and any other minerals needed for maximum utilization of range forage for bone building,

growth, and lactation. Research is needed to determine mineral deficiencies of local forages.

For more detailed information on management of rangelands, see Technical Bulletin No. 23, issued by the Office of Agriculture, Bureau of Science and Technology, Agency for International Development, Washington.

C. Forage production and utilization on rangelands

Most rangelands occur in regions of limited rainfall. Exceptions are those areas of shallow soil, or soils with impervious soil layers in the profile, occurring in regions of more adequate rainfall. In such areas, the land is not arable, and is not used for crop production, since any crop yields are low and undependable. Because of the low soil moisture in such exceptional soils, they are actually subject to drought injury, as in regions of limited rainfall.

The amounts of useable forages produced on rangelands in regions of limited rainfall, varies widely from year to year, and from locality to locality. The rainfall in such regions usually occurs in brief local showers, rather than widely spread rains. (The exception is the region of winter rains in North Africa and the Middle East, from Morocco in a crescent to Pakistan, where cool seasonal rains generally are wide spread.) The localization of rains in sub-humid and semi-arid regions may be evened out in some years by intermittent showers occurring at random; and thus a particular locality may be missed in one rain but covered in a subsequent rain. But there often are local areas that receive little or no rain. In general, semi-arid regions have greater uncertainties as to occurrence of rains than in sub-humid regions.

Since rainfall occurrence is a major factor in producing forage on rangelands, it is important to have a continuing record of seasonal rains during the plant growing season, as well as their geographic distribution.

Where governmental land tenure policies on utilization of rangelands permit the allocation of exclusive use rights on a long-term basis, for specific geographic areas, by identified communal or other groups of farmers and herders, it is possible to develop management systems to greatly improve productivity of rangelands. These rangelands now are generally degraded by excessive stocking rates that result in over-grazing, weakening of the useable forage plant cover, excessive runoff losses of rainfall, invasion of woody shrubs and useless types of vegetation, and often by uncontrolled soil erosion. This is the result of the current general operational policy of permitting the first herdsmen who brings his stock onto a locality to take all the forages that are produced (as well as stock water). Since agriculture should include both arable lands and grazing lands, and both crops and livestock, the omission of suitable controls of grazing lands usually defeats development of a modern utilization system. Such a system should provide the subsistence needs of family units for the improvement of available rangelands, and for substantially increased productivity of livestock.

More effective managment of rangelands to improve forage production and to increase the yields of livestock herds and flocks is needed to halt continuing degradation of rangelands, and to provide much more dependable outputs of ruminant livestock and their products. The interrelation of arable lands (with their crop by-products and residues to support livestock) with permanent grazing lands for seasonal forage supplies constitutes a basic framework for more productive agricultural systems.

Productive management of the range grazing land, and of the ruminant livestock alloted to the range, requires that a management program be agreed upon by all authorized users, and the designation of a manager(s) to carry out the program.

The management program should identify the range area, authorized exclusive and sustained use by the livestock owners, and the procedures to be impelemented. Governmental authorization and enforcement of use-rights to specified rangeland areas is a prime requirement. The program of use should maximize the support of the grazing herds and flocks that is feasible under the conditions of lands, soils, and forage production expected on the range areas in response to anticipated rains. This program will plan for stocking rates that permit the growth and survival of desirable forage plants, without depeleting forage plant strength; and thus insuring greater forage production in the ensuing years.

To insure effective implementation of a program, the rangeland area should be subdivided into 3 or 4 sectors, so that each sector can be grazed in rotation. The goal is to permit livestock to consume up to one-half of the available green forage on a chosen sector, and then moved to another sector. The length of the grazing period on each sector must be adjusted to the rate of forage plant growth. If the seasonal forage growth is less than anticipated, the individual grazing period must be shortened, and the stock moved to the next sector. The accepted plan should provide for reducing total livestock numbers to avoid over-grazing and weakening of the forage plants.

When all range sectors have been grazed to a level that protects the amount of green leaf and stem needed for forage plants to maintain strength, and to store plant food in forage plant crowns and roots, grazing should cease, and

the stock moved to other feed sources. These may be the crop by-products, and residues produced on arable crop lands. Any stored feedstuffs in the form of chopped dry stalks and leaves, or hay, or silage will be most useful. However, soil improving grass-legume crops grown in rotation on arable lands also may be utilized when range forage is depleted.

The above plan involves moderate grazing to effectively utilize growing forages on permanent grazing lands. This system not only provides a more adequate ans sustainable feed supply for livestock, but it also protects the productivity of the range area for the following season. When well-managed, the total livestock output in weight grains, reproduction (of calves, lambs and kids) and reduction of animal losses will be substantially improved. There are many instances of greatly improved production on well-managed range-lands in the dry regions of North America and Australia where low rainfall environments resembles those of extensive range areas of developing countries.

When all forage plant growth has ceased after the termination of seasonal rains and the plants' top growth is no longer green, it is feasible to initiate a new cycle of grazing to utilize such standing dry forage. However, the grazing should cease when the plant cover is grazed down to about 10 cm. This "stubble" is needed to prevent wind erosion during the dry season. and to reduce rainfall runoff at the beginning of the ensuing rainy season. Denuded grazing lands accentuate rainfall losses. The plant cover is the most effective means of retarding rainfall from escaping, so that it may infiltrate into the soil profile and thus support renewed plant growth.

An alternate method of utilizing late season forage growth is feasible in some favorable seasons, on areas where woody vegetation is not abundant. Such

forage may be cut and made into hay. Standing dry forage rapidly loses its feed value by natural weathering, and prompt harvest as hay is a means of fully utilizing such dry forage without weakening the stand of forage plants.

The encroachment of woody shrubs and other useless plant growth should be halted by periodic clearing of rangeland during the dry season when labor is available. Such clearing is most useful in conserving rainfall in the ensuing season for support of desirable forage grasses and legumes. The planned introduction of superior grasses and legumes may be undertaken on lands where useless vegetation has been removed. Such reseeding should be made at the beginning of the rainy season, on areas that can be protected from grazing during the first growing season of the introduced plant species.

Figure 3. Ruminant livestock are produced in developing countries on herbaceous forages, without grain.

Figure 4. Cattle, sheep and goats are produced on permanent grazing land (rangelands) in regions of limited rainfall. Production may be greatly enhanced by supplying supplemental feed in the dry season, produced by harvest and storage of crop residues and by-products of arable farm lands.

XI. Cultural Practices to Enhance Production of Herbaceous Forages* on Arable Croplands

A. For producing by-products and crop residues of crops grown on arable lands, all cultural practices that foster higher yields of cultivated annual crops also will increase the quantity of forage by-products and crop residues from croplands. There is no detriment to crop yields from a program of conserving such forages.

The basic production factors will include the following:

1. Selection of crop types that are adapted to local climates, soils, human food needs, and potential markets.

2. Land management to conserve rainfall, control soil erosion hazards, and be acceptable in terms of land preparation for planting, as well as be within the limits of available human labor.

3. Prior testing of representative soil samples to evaluate the needs for fertilizers or soil amendments that will meet mineral nutrient needs of the crop to be grown.

4. Appropriate application of fertilizers and soil amendments, by placement under the crop row for rapid benefits to plant growth. A feasible practice is to open the proposed crop row by furrowing, distribute fertilizer in the open furrow, and cover with about 2 cm. of soil. Seed may then be placed and covered lightly with soil. Such planting should occur at the beginning of the growing season as soon as the soil is moist enough for movement.

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*For detailed production practices for individual crop species, see: "Guide for Growing Field Crops in the Tropics and Subtropics," published by the Office of Agriculture, Bureau of Science and Technology, Agency for International Development, Washington, DC.

5. Animal power is most effective in land preparation; and it's appropriate use would reduce human labor requirements by a factor of at least 4. This would deal directly with a major constraint in crop production. Draft animals (oxen and buffalo) and a two-wheeled cart would be labor serving in moving production inputs into the field, as well as carting crop harvests, by-products and residues to appropriate storage facilities.

6. Improved varieties (cultivars) of the selected crop types, that are adapted to the local environment, are high yielding, resistant to insect pests and diseases of each crop, and are readily harvested and stored, should be included in the cropping system. The actual field testing of available varieties is a proper function of a national agricultural research station.

7. Seed for planting of improved varieties of each crop should have high germination, and be free of seed-borne diseases. The plant population that will fully utilize the light, moisture and soil nutrients is a basic requirement. With high quality seed, the seeding rate may be such as to provide full occupation of the land, but avoid excess plants that may exhaust soil moisture and nutrients before the full growth potential is reached. Appropriate seeding rates should avoid the necessity of thinning, which is a high labor constraint. Bulk planting of low quality seed is a ruinous practice.

8. Weeding is a labor consuming practice and should be minimized to the extent possible. Rotation of crop types so that no crop is grown in the same field in successive years is an inexpensive but very effective way of reducing abundance of weeds, as well as insect pests and plant

diseases. Such pests usually favor specific host crops, and the pests multiply when there is no crop rotation. Weeding may also be reduced by placing all fertilizer in bands beneath the crop row, where the crop will derive the major benefit, and not the weeds.

Early tillage or hoeing to kill weeds is most effective and less labor consuming than attacking weeds after they are well established. Further, early weed control also will improve crop yields. Delayed weeding places a constraint on crop development, and attacking well-developed weeds often damages the root system of the crop, which reduces yields.

9. Crops should be harvested as soon as matured, to avoid crop losses by shattering, weather damage, seed diseases, insect attacks, etc. This prompt harvest also permits immediate harvest of green stalks and leaves, vines and other by-products while they have good feed value for livestock. The common practice of allowing crop plants to stand in the field after harvest of grain seed or roots results in losses of 50 to 75% of the potential feed of the associated herbaceous forages. Thus, the prompt harvest of crops provides maximum conservation of the grains, seeds or roots; as well as permitting maximum conservation of the by-product herbaceous forages for support of livestock.

B. Production of annual herbaceous forages on arable lands, in rotation with harvested crops:

1. The inclusion of annual forages in the crop rotation has important advantages. These annual forages, if properly selected, will improve soil structure for succeeding crops, by the fibrous root systems of the forage grasses, and by the nitrogen added to the soil from the companion leguminous forages. The conservation of rainfall and control of soil erosion is an additional benefit. These annual forage mixtures are high in crude protein content and make excellent supplemental feed for livestock. The cultural practices for these forage mixtures may closely follow those for gain and seed crops, in land preparation, choice of fertilizers and early season planting.

2. The selection of annual forage mixtures should be adjusted to the climatic conditions as follows:

a. For the tropical regions:

Mixture No. 1 - Sudan grass, plus vining type of cowpeas.

Mixture No. 2 - Pearl Millet, or Sorghum, plus the vining type of cowpeas.

b. For close planting (as practiced for wheat, barley, or rice), the amounts of seed may be 30 kg/hectare for sudan grass, and 45 kg/hectare for cowpeas. No tillage of the growing crops is required. A first cutting for hay or green feed is feasible in about 8 weeks after planting. The cutting should be at a height of 15 to 20 cm., to leave a stubble for fast regrowth. A second cutting may be harvested when the sudan grass produces heads.

c. For Mediterranean climates (North Africa and Middle East):

Mixture No. 1 - Rye grass and vetch. Proposed seeding rates are 20 kg/hectare of rye grass and 30 kg/hectare of vetch. This crop should be close planted (as for wheat and barley) and no cultivation is required.

Mixture No. 2 - Annual Canary grass and grass pea (vetchling). Proposed seeding rates are 20 kg/hectare of Canary grass and 20 kg/hectare of grass pea. Planting should occur as soon as cool season rains provide moist soil.

The first cutting of each mixture should be made in mid-season of the favorable growth period, and the second cutting toward the close of the cool season of rains. The first cutting should be made at height of 15 to 20 cm., to leave a stubble for fast regrowth.

C. Production of forage on permanent seeded pasture areas:

See preceding Section IX for further details on establishment of such plantings. When once established, such areas may either be grazed intermittently, or cut for hay when top growth appears to have reached a maximum. This forage should be rich in crude protein, if the legume in the mixture is adapted and vigorous; and the hay will constitute an excellent supplemental protein to accompany other dry forages or silages.

In humid regions the forage on such plantings may be cut and fed green, harvested at about 4 weeks intervals. The green feed is a satisfactory supplement for milking animals and for fostering rapid growth of young stock after weaning.

In all regions having a substantial dry season, the forage may be cut for hay when rains have ceased, and stored for supplemental feeding as needed.

Figure 5. Animal power has great value in developing countries, for work that is necessary to grow crops. Animal power should be developed to replace human labor that is excessive in land preparation and tillage, crop management, and crop harvest.

XII. Harvesting Forages

A. Stalks and leaves of maize, sorghum and millet.

There is widespread waste of such coarse stalked crops grown for grain. To conserve these by-products for livestock feed, the grain should be removed promptly when ripe, and the stalks and leaves chopped and sun dried for storage. The stalks and leaves should be cut promptly while still green, and chopped for storage. An effective method is to chop stalks and leaves into pieces about 4 to 5 cm long, in a mechnanical chopper. These chopped stalks may either be made into silage (see later section on making silage) or placed in stacks for natural stack curing. The forage should be strongly packed down as the stack is formed. The cured product produced by natural fermentation, makes excellent feed for the dry season.

B. Harvesting tops of groundnuts, for all types of peas and beans, and for other legume seed crops. The prompt removal of the ripe seed pods, will permit harvest of the tops to be saved for feed. Chopping is usually not needed for such tops. They may be stacked on a location near the feeding racks for convenience, or placed on raised platforms to be out of reach of the livestock.

C. Where termites constitute a problem, both of the foregoing forages may be placed on land areas that have been treated with appropriate pesticides to prevent termite invasion. It should be noted that grain legume tops are excellent high protein feeds even when leaves are lost. This valuable feed is lost if left in the field.

D. Making hay in the Tropics and Subtropics.

Appropriate practices include:

1. The growing forage plants should be cut after all dew has evaportate from the leaves (usually by midmorning). The forage should be left in a swath during the day of cutting for sun drying.

2. Assuming there has been no rain after cutting, the swaths may be collected in piles after mid-morning of the next day and transported to the selected open-storage site.

3. The air-dried (cured) hay may be piled on a raised platform) above reach of animals) until fed. This will protect against animal feeding and may prevent loss by termites.

4. An alternate storage method is that of stacking on a well-drained ground area, previously treated with insecticide to repel termites. The stack area should be well fenced to exclude livestock.

5. Hay stacks may be as tall as 10 meters; and when hay is well dried before stacking it should remain edible for many months.

6. If forage is to be placed in feeding racks or stalls, it may be convenient for hay stacks to be located near feeding areas.

7. When hay stacks may be exposed to rain during storage the stacks should be provided with a cover of thatched grass or a plastic sheet to shed water.

8. In situations where rains are expected (as in humid tropics) forages should be made into silage, rather than attempting to make hay.

9. Machinery for making hay.

There are several tools for harvesting and handling hay. The hand sickle and the scythe are hand tools for cutting forages for hay. A two-handed scythe may be 4 times as fast as a hand sickle for cutting. A wooden hay rake is needed for gathering of cut forage. A 3-tine or 4-tine pitch fork is a customary tool, both for stacking hay, and for moving hay to feeding racks.

Where local farm cooperatives are available for machine services, field mowing machines mounted on tractors will mow and place in swath the standing forage plants at rapid rates; and are highly mobile for moving from field to field, and farm to farm.

Hauling hay from the field to the farm stack area, or to the vicinity of feeding racks, is expedited by an ox-drawn 2-wheeled cart. Such a cart is useful also for transport of green-cut forage from the field to the feeding area.

E. Making silage out of forage plants.

1. Silage is made by chopping green grasses and legumes, or green stalks and leaves of maize, sorghum or millet, into lengths of about 5 cm or shorter, followed by packing into enclosed areas (trench silo) for fermentation and storage. If the forage grasses or legumes are quite succulent, some field wilting before placing the crop in storage is desirable.

2. The fermentation process occurs naturally, and will reach a stable state in a few days; and the forage will remain as edible feed for months. To insure desirable fermentation, the plant material should be tightly packed to exclude air, and covered with a plastic sheet promptly to prevent later aeration. The plastic cover should be made air-tight by covering the edges with soil.

3. Forage silage is the preferred method of preserving feed in the humid tropics; and is an alternate method for all climatic zones when weather conditions are unfavorable for making hay. Silage may be made in open storage areas, but they must be well drained; and the placement of the forage and exclusion of air is necessary to produce nutritious feed without spoilage.

4. The feeding value of silage can be no better than that of the plant material preserved; but silage may preserve nearly all of the feed value in those plants. In comparison with dry hay or straw, 3 kg of moist silage will provide about as much feed value as 1 kg of dry forage. A higher percentage of the feed values of forages is saved by making into silage, than when cured as dry feed. Conservation of feed by making into silage is most valuable in rainy seasons.

5. Chopping green forage, to be made into silage.

It is essential to provide a chopping machine, to cut green forage into lengths of 5 cm or shorter, so that the material may be tightly packed in the trench or silo, to exclude air and to foster the desired natural fermentation that preserves the feed in a palatable state. Hand propelled, stationary chopping machines are feasible, but require manpower. Where farm cooperatives are available to provide machinery services, motorized choppers are desirable. Such choppers are easily moved from farm to farm, and the power requirements may be met by small engines (gasoline or diesel). A single machine chopper will serve many farms.

XIII. Feeding stored forages to Ruminant livestock.

Such feeding will generally take place during the dry season, which has different lengths in different climates.

	Length of Dry season
Wet-Dry Tropics	3 to 5 months
Sub-Humid Regions	5 to 7 months
Semi-Arid Regions	7 to 10 months

During the seasons of rains, it may be possible to meet the feed requirements of mature ruminant livestock with local grazing lands. However, such grazing land may prove inadequate for the following classes of animals:

A. For work animals. During the season of rains, for land preparation, planting, cultivation, etc., supplemental feed is essential to maintain animal strength and avoid weight losses. These animals are important and must be fed adequately. Thus, feeding rations for work animals should be essentially based on stall feeding and not on pasture.

B. For milking animals (cattle, buffaloes, goats and sheep). Additional forage supplements should be offered during the grazing season to maintain milk flow.

C. For young stock after weaning. Additional forage protein supplement should reinforce any available pasture, to produce strong healthy animals.

D. The following guidelines should generally apply to the daily feed ration of ruminants during the dry seasons.

1. For maintenance of mature animals, when grazing is no longer meeting feed needs: Six kilograms of dry forage, per day.

2. For work animals, actively working six kilograms of dry forage, per day plus, two kilograms of forage protein supplement per day.

3. For milking animals:

(a) Large ruminants (cattle, buffaloes) six kilograms of dry forage per day, plus, two kilograms of forage protein supplement per day.

(b) Small ruminants (goats and sheep) for 5 goats or 5 sheep, supply feed equal to one large ruminant.

NOTE: For high yielding milk animals, additional forage protein supplement may be needed to prevent animal weight losses.

4. For young stock (from weaning to fully grown)

(a) For large ruminant calves, per head, per day: 3 kilograms per head of dry forage, plus, one kilogram per head of forage protein supplement.

(b) For kids and lambs: for every 5 head - five kilograms of dry forage, plus, one kilogram of forage protein supplement.

5. Adjusting green weights of forage for direct feeding (without storage):

Four kilograms of fresh green weight, equals one kilogram of dry weight. Three kilograms of cured silage equal one kilogram of dry weight.

6. Types of cured forages.

(a) Hay is dried crops of fine stemmed grass forages; or grass-legumes mixtures.

(b) Straw is cereal grain stems (wheat, barley, rice) after grain is threshed out.

(c) Dry stalks (of maize, sorghum, millet) are stalks and leaves after removal of grain by chopping and stacking for natural curing in the open.

The above forages are assumed to be about 50% digestible when consumed by ruminant livestock. The crude protein content may average 6%.

E. Forage protein supplemental feeds include:

(1) Dried tops of groundnuts, all peas, all beans, and any other leguminous grain crops.

(2) Mixed annual grasses and legumes grown as soil improving crops in crop rotations; and usually made into hay for storage.

(3) Permanent legume plantings, usually on non-arable lands, to be cut and fed green, or made into hay. These plantings may include grasses, but the forage legumes should predominate.

XIV. Feeding facilities for supplying forages to ruminant livestock.

Controlled feeding of forages requires facilities to insure feeds are effectively used.

A. Feeding work animals, (Oxen).

These animals may be stall fed, or kept loose in small pens, with a feeding rack and drinking water. Freedom of movement is desirable and adequate water is essential. Manure should be collected for subsequent application on crop land. Feed should be available when animals are penned.

B. A commodious fenced feed inclosure is essential for all other ruminant livestock, but it should be subdivided by fences into 3 sections as follows:

1. For milking females to permit night separation of nursing young until after morning milking. This section should have feeding racks of two types: one type with widely spaced vertical slots, for large animals, and a second type with more narrowly spaced vertical slots that will admit only goats and sheep.

Feeding may occur in evening and early morning. Water must always be available for milking females, since milk flow depends on ample water supplies.

2. For young stock (from weaning to fully grown). A section with separate feeding racks, one for larger stock and one for samller stock. Water should be available at all times.

3. For mature dry stock. The feeding racks should be in 2 sections; one for large ruminants, and a second rack for sheep and goats. Adequate water should be provided for one unlimited drinking each day.

C. Enclosures for stored forages.

Stored forage for feeding should be stacked near the fenced feeding area for convenience in daily feeding. However, this stored forage area should be adequately fenced to exclude any roaming animals at all times.

The fenced area for feed storage may also be made large enough to permit storage of all manures that may be collected from the feeding pens until it can be aplied to crop lands.

D. Estimating weights of forages placed in feeding racks.

Since scales for weighing forage are not available on most farms in developing countries, the agricultural advisor for the district may be asked to estimate the equivalent volume of the forage at hand that will approximate the desired weight of feed allotments specified in the foregoing sections. Handling forage feeding is facilitated by use of hand hay forks, usually with wooden handles, and 4-steel tines. An average fork-load of the forage at hand, may be estimated in terms of weight. Thus, feeding may be carried out daily in terms of fork loads.

XV. Selected References relating to the Production Storage and Utilization of Herbaceous Forages for Support of Ruminant Livestock in Developing Countries of the Tropics and Subtropics.

1. The Role of Ruminants in Support of Man. 1978. Published by Winrock International Livestock Research and Training Center, Morrilton, Arkansas 72110

2. The Role of Sheep and Goats in Agricultural Development. 1977. Published by Winrock International Livestock Research and Training Center, Morrilton, Arkansas 72110

3. Animal Agriculture in Indonesia by A. D. Tillman. 1981. Published by Winrock International Livestock Research and Training Center, Morrilton, Arkansas 72110

4. The Status and Challenge of Dryland Agriculture in Developing Countries of the Tropics and Subtropics by Howard B. Sprague. 1981. Published by Rural Development Division, Bureau for Program and Policy Coordination. U.S. Agency for International Development, Washington, DC.

5. Combined Crop/Livestock Farming Systems for Developing Countries of the Tropics and Subtropics by Howard B. Sprague. 1976. Published as Tech. Bul. No. 19, Office of Agriculture, Technical Assistance Bureau, U.S. Agency for International Development, Washington, DC

6. Management of Rangelands and Other Grazing Lands in the Tropics and Subtropics, for Support of Livestock by Howard B. Sprague. 1979. Published as Tech. Bul. No. 23, Office of Agriculture, Technical Assistance Bureau, U.S. Agency for Internationa velopment, Washington, DC

APPENDIX TABLE A. Herbaceous Forages - Number of Agricultural Family Work Units[1] in Representative Countries

Countries	Economically Active Agricultural Population (000)	Estimated Number of Agr. Family Units (000)	[2]Number of Agricultural "Multiplier" Units (000)
AFRICA			
Botswana	306	51	51
Cameroon	3,162	527	527
Ghana	2,197	366	366
Kenya	4,811	802	802
Liberia	476	79	79
Malawi	2,299	383	383
Mali	3,105	517	517
Niger	1,449	241	241
Senegal	1,743	290	290
Sudan	4,377	729	729
Swaziland	184	31	31
Tanzania	5,928	988	988
Togo	752	125	125
Upper Volta	2,986	498	498
Zaire	8,855	1,476	1,476
Zimbabwe	1,424	237	237
NORTH AFRICA & MIDDLE EAST			
Egypt	5,997	1,000	1,000
Jordan	196	33	33
Lebanon	81	14	14
Morocco	1,739	456	456
Syria	1,050	175	175
Tunisia	619	103	103
Yemen	1,228	209	209
ASIA			
Bangladesh	25,311	4,219	4,219
Burma	7,294	1,216	1,216
Indonesia	30,538	5,090	5,090
Nepal	6,264	1,044	1,044
Pakistan	11,937	1,989	1,989
Philippines	8,100	1,350	1,350
Sri Lanka	1,754	459	459
Thailand	16,088	2,681	2,681
LATIN AMERICA & CARIBBEAN			
Bolivia	909	151	151
Costa Rica	260	43	43
Dominican Rep	877	146	146
Ecuador	1,135	189	189
El Salvador	754	126	126
Guatemala	1,211	202	202
Guyana	63	11	11
Haiti	1,936	323	323
Honduras	681	113	113
Jamaica	157	26	26
Nicaragua	347	58	58
Panama	225	37	37
Paraguay	482	80	80
Peru	1,954	326	326

[1]Assume an average of 6 mature workers in each family unit. The range in number of workers may vary from 4 to 8.

[2]Where recorded data is available on size of working adults per family unit is available, substitute such numbers for the assumed figure of 6 working adults.

APPENDIX TABLE B Numbers of Ruminant Livestock in Representative LDC Countries* (1980 FAO data)

	Cattle (000)	Buffaloes (000)	Goats (000)	Sheep (000)	Total Animal Units** (000)
Africa					
Botswana	2,911	0	1,250	638	3,289
Cameroom	3,200	0	1,230	2,160	4,100
Ghana	950	0	2,100	1,700	1,710
Kenya	11,000	0	4,530	4,300	12,766
Liberia	40	0	200	200	120
Malawi	823	0	630	75	964
Mali	4,422	0	5,798	6,120	6,805
Niger	3,206	0	7,318	2,600	5,189
Senegal	2,789	0	890	1,919	3,351
Sudon	18,354	0	12,570	17,800	24,428
Swaziland	660	0	270	34	721
Tanzania	12,673	0	5,686	3,790	14,568
Togo	260	0	750	840	578
Upper Volta	2,760	0	2,800	1,850	3,690
Zaire	1,170	0	2,722	738	1,862
Zimbabwe	2,151	0	1,350	590	2,539
North Africa and Middle East					
Egypt	2,040	2,379	1,700	1,692	5,097
Jordon	39	0	564	924	338
Lebanon	110	0	380	280	242
Morocco	3,680	0	6,070	16,100	8,114
Syria	770	3	1,000	8,800	2,730
Trinisia	914	0	922	4,967	2,192
Yemen	950	0	7,300	3,200	3,050
Asia					
Bangladesh	33,000	1,500	11,500	1,061	37,062
Burma	7,702	1,803	577	217	7,861
Indonesia	6,473	2,353	8,051	3,611	11,108
Nepal	6,900	4,200	2,500	2,360	12,072
Pakistan	15,038	11,547	30,203	26,239	27,873
Philippines	1,885	2,760	1,450	30	4,941
Sri Lanka	1,623	830	470	25	2,552
Thailand	5,000	6,250	31	61	11,268
Latin America					
Bolivia	4,000	0	3,000	8,750	6,350
Costa Rica	2,183	0	1	2	2,183
Dominican Republic	2,153	0	380	54	2,240
Ecuador	2,366	0	247	2,313	2,878
El Salvador	1,440	0	15	17	1,446
Guatemala	1,653	0	76	679	1,804
Guyana	295	0	70	114	332
Haiti	1,100	0	995	89	1,317
Honduras	2,200	0	15	3	2,223
Jamaica	300	0	380	6	377
Nicaragua	2,401	0	7	2	2,403
Panama	1,525	0	6	0	1,526
Paraguay	5,203	0	127	423	5,313
Peru	3,837	0	2,000	14,473	7,132

* Data from FAO Production Yearbook. 1980

** Animal Units: 1 Cow or 1 Buffalo = 1 Animal Unit. 5 Goats, or 5 Sheep = 1 Animal Unit.

APPENDIX TABLE C Estimated Food Crop Residues Suitable as Feedstuffs for Ruminant Livestock in Developing Countries of the Tropics and Subtropics.

CROP RESIDUES AN 10-HECTARE AREA	TOTAL DRY MATTER
A. Humid Climatic Zones:	
Average yearly rainfall: over 2,000 mm Length of dry season: less than 2 1/2 mo.	5,000 Kg.
1. Two hectare of cereal straws (rice, wheat, barley)	
2. Four hectares of green stalks and leaves of grain crops, after grain harvest (maize, sorghum, millet)	15,000 Kg.
3. Two hectares of tpes from food grain legumes: (groundnuts, peas, beans, cowpeas, mung beans, etc.)	5,000 Kg.
4. One hectare (of sweet potato vines, cassara tops, etc.)	1,500 Kg.
5. One hectare of unmarketable crops (vegetables, root crops, sugar cane tops and volunteer forages along roads, ditches and on untillable small plots)	1,500 Kg.
for 10 hectares:	28,000 Kg.
B. For Wet-Dry Climate Zones	
Average rainfall: 1,000 to 2,000 mm. Length of dry season: 3 to 5 months One half of humid zone yields	14,000 Kg.
C. For Sub-humid and Mediterranean Zones	
Average rainfall 500 to 1,000 mm One third of humid zone yields	9,000 Kg.
D. For Semi-arid Zones	
Average rainfall: 250-500 mm. Length of dry season: 7 to 10 month One-fifth of humid zone yields	5,0000 kg.

For all regions it is assumed that effective crop cultured practices will be applied; including use of fertilizers and soil amendments to correct soil fertility deficiencies.

APPENDIX D

Illustration of A Successful System for Dairy Production in the Humid Region of Central America*

Summary

The system takes into account the resources and constraints that are characteristic of small farms in Central America; but constitutes a practical milk production system. Ample use of pastures (as major feed source), moderate use of agricultural by-products (molasses), and minimum use of whole milk (for calves) are characteristic of the feeding components. Moderate milk production per unit of land area is possible, using Crossbred cattle (native Criollo x Jersey) of small or moderate body size, and a fast growing pasture grass species. The system produces 15,000 kg of milk per hectare, per year. Economic analyses of this dairy operation in the humid tropics (600 meters altitude), indicates a net profit of 35% including all operational and fixed costs.

Description

The module of milk production is based on the intensive use of a fast growing grass, which requires moderate amounts of fertilizer, and rotational grazing. It occupies an area of 3.8 ha. of flat but poorly drained land, divided into 25 paddocks of 643 square meters each. The larger paddocks are grazed by 20 adult cows and 8 heifers, while the smaller paddocks are for calves and younger heifers. In total, the stocking rate is 6.5 cows per hectare.

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*Preliminary report: "A system of milk production for small farmers," by M. E. Ruiz, G. Cubillos, P. Deaton, and H. Munoz. Tropical Agricultural Research and Training Center, Turrialba, Costa Rica.

Feeding Component

Both cows and calves graze African Stargrass. The milking cows change paddocks daily, although dry cows and heifers graze the paddock left by the milking cows, for one additional day. After each paddock is completely vacated, fertilizer is broadcast. The rate of fertilization is 500 kg. of a 20-10-6-5 mixture, and 545 kg of urea/per hectare/per year. The applications are made only during the wettest 8 months in theyear; therefore, after each grazing cycle, the equivalent of 50 kg of urea is applied per year. In addition the manure (cow droppings) is evenly distributed in each paddock as it is vacated. Weed control is carried out by machete (by hand).

The milking cows receive a total of 1 kg of Blackstrap molasses containing 3% urea, divided into 2 equal parts, each part offered at the time of milking. No feed supplements other than mineralized salt and bone meal are otherwise provided.

With respect to the feeding of the calves, these receive approximately 180 kg of whole milk during the first 2 months of life, after which time milk is (gradually) withdrawn from the feeding program; when the calves are one-week old, they are placed in paddocks (for grazing) during the day. Each (calf) paddock is grazed for 3 consecutive days. Supplementation with a 24% crude protein ration is provided, not exceeding 2 kg/per calf/per day.

The ration (concentrates) offered to calves from birth to 6 month of are is:

Ingredient	Percent, as fed
Yellow corn (ground)	44%
Fish meal	20%
Meat and bone meal	4%
Black strap molasses	18%
Wheat bran	10%
Common salt	1%
Vitamins and mineral mix	2%

A night-time shed is available until calves are one-year old.

Health Control

At time of birth, calves have navels treated with an iodine solution, and are vaccinated against septicenua, black leg, and malignant edema. Between 4 and 6 months, a vaccine against brucellosis is given. At 8 and 12 months of age, septicema vaccinations are repeated.

The replacement heifers and cows are treated against internal parasites every 3 months. Ticks are controlled periodically, depending on the severity of infestations. The milking cows are tested for mastitis on a monthly basis.

Construction

The peripheral fence is of the elastic type, using smooth wire. The paddocks are divided with electric fences. Two walk-through stanchions are used. Other equipment is standard to dairy farms, such as calf pens and milking machines.

Labor

One farm worker is in charge of all operations--milking, cleaning, fence repair, distribution of manure in fields, weed control, fertilization, weeding, and disease and parasite control. Occasionally, help is provided to accomplish major tasks, thus resembling actual situations found at a typical small dairy farm.

Performance Data: 1976-1979

Milk/cow/year in kg	- 2,805 kg
Milk per cow lactation	- 3,039 kg
Milk per hectare, per year	- 15,000 kg
Stocking rate	- 6.5 cows/ha.
Calving Interval, months	- 13.0 months

Economic Data

Value per milking cow	- $820.00 per head
Farm labor	- 6.90 per day
Blackstrap molasses	- 35.00 per metric ton
Urea	- 246.00 per metric ton
Concentrates, 24% crude protein	- 212.00 per metric ton
Land rent	- 70.00 per hectare per year
Income from milk sales @	- 0.28 per kg
Agricultural land, annual interest	- 12%
Total investment for module	- $26,000.00; to establish a 3.8 hectare module, and to operate in the first year.

For the module, total production amounts to 57,000 kg milk in one year; gross income = $17,000 per year.

Net annual income is $4,465.00 for the module; or, $1,175.oo per hectare per year.

Total net profit in excess of 35% per year.

Favorable Conditions for Successful Establishment and Operation of Dairy Modules in Costa Rica

1. Elevation of 600 meters (1800 feet) where climate permits use of western dairy breeds, particularly when he native Criollo cattle are used for upgrading by crossing (on Jersey). The climate is humid tropics with only occasional dry periods.

2. Availability of molasses, mineralized salt, urea, and mixed fertilizer in producing pasture forage; and utilizing such pasture under a controlled system of management for the dairy herd.

3. A satisfactory market for fluid milk, an efficient collection system, and a competent milk processing plant.

4. Available crop products such as banana stems and reject fruits, sugar cane tops and leaves, etc.

5. Availability of farm production credit, and a reliable agricultural advisory service for the dairy farmers.

6. Humid climate with well-distributed rainfall, and pastures that are actively growing at all seasons.

Turrialba has altitude of 600 meters (= about 1800 feet).