INTENSIVE PRODUCTION SYSTEMS FOR PASTURES IN THE HUMID TROPICS

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ABSTRACT

The author of this paper has been working at MCFARM Sendirian Berhad, a wholly owned subsidiary of Mitsubishi Corporation, as Deputy Project Manager responsible for the technical and engineering aspects of the operation of this farm.

MCFARM was established in response to the wish of the Government of Brunei Darussalam, who expected Mitsubishi to set up a cattle breeding project in Brunei Darussalam.

Brunei Darussalam is the oil and gas rich sultanate located in North Borneo which is enjoying prosperity and both social and economic stability. Because of the typical wet tropical climate, however, the agricultural development in Brunei Darussalam has been difficult. The difficulties encountered in the livestock industry are related to the aggressive growth of shrubs and local grasses in pasture fields and the high acidity of the soil due to the abundant rainfall. All these factors make it very difficult to maintain a stable supply of cheap feed for cattle.

In such an environment, MCFARM has attempted to develop a technology for the livestock industry which can be easily transferred to ordinary farmers in Brunei Darussalam. The efforts made in the last five years have resulted in establishing a technology for cattle breeding in Brunei Darussalam which can also be applied in other tropical regions.

The achievements at MCFARM have paved the way for the future development of the livestock industry in Brunei Darussalam which should enable the country to attain a reasonable level of self-sufficiency in the supply of meat.

This paper introduces technological aspects in the planning, development and operation of the farm in the last eight years, with emphasis placed on the development of pasture.

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Location of MCFARM

MCFARM is located on hills at 4° 56′ North latitude and 114° 52′ East longitude and at an elevation of 12-54 meter above the sea level in the tropical rain forest zone along Jalan Tungku which is situated about 10 km northwest from the capital of Negara Brunei Darussalam, Bandar Seri Begawan (Fig. 1).

Natural environment

In compliance with the request from the Government of Brunei Darussalam to establish a cattle farm, a preliminary survey was initiated in November 1976 on the climate, topography, soils and vegetation of the region.

The survey involved eight different sites proposed by the Government of Negara Brunei Darussalam in taking into consideration the moist climate of Borneo Island and the need for devising methods of control to cope with possible problems including the various diseases

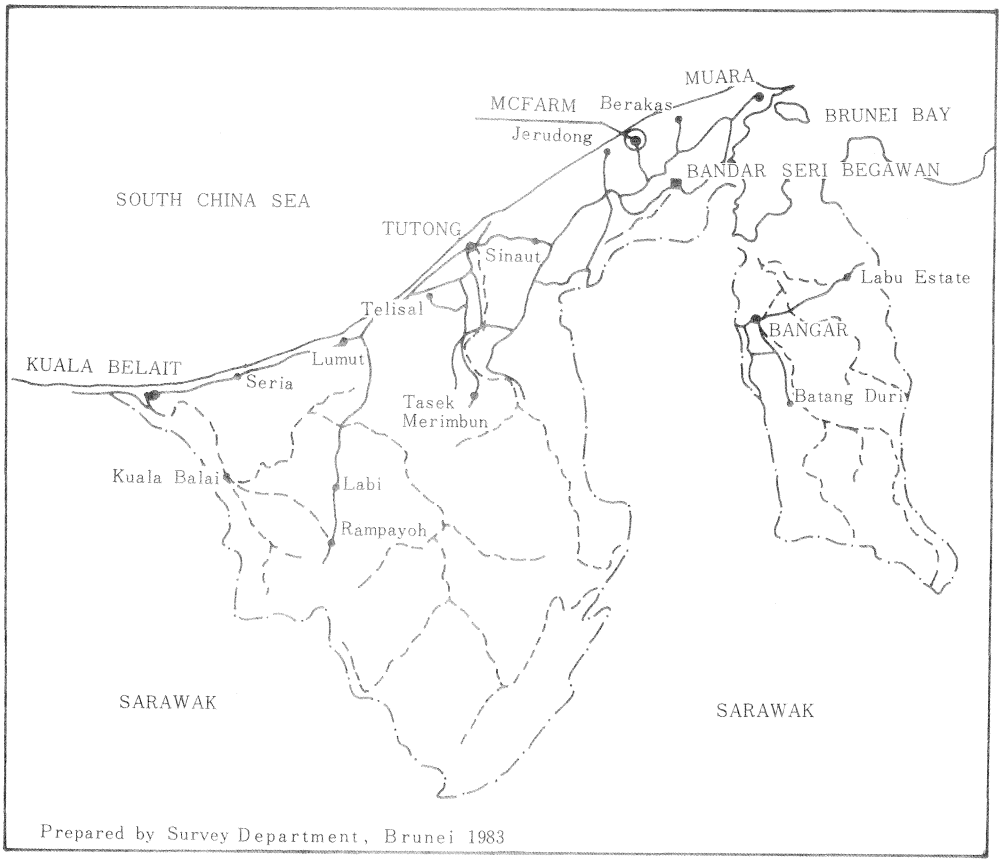


Fig. 1 Location of MCFARM.

associated with a tropical climate.

About 450 acres of relatively flat area were selected as the site for establishing the farm, as outlined previously.

The rainfall in this area is in the range of 2,500-4,000mm (98-157 inches) per year and heavy rain occurs usually from December to January. There is a relatively dry season from April to June although there are no distinct dry or rainy seasons. The weather is irregular and there is no fixed seasonal pattern throughout a year.

Anaplasmosis and parasitic diseases are the major obstacles to the development of a tropical cattle industry. The interval of the spawning season of tick is shortened with the rise of temperature. Parasite outbreaks may occur in an unpredicatable manner in Brunei and particularly tick outbreaks cause massive economic damage to the cattle industry due to the occurrence of tick fever, with ticks being the vectors of anaplasmosis.

The characteristics of the climate in Brunei Darussalam can be summarized as indicated below (Table 1, Fig. 2, Fig. 3).

1 There are no distinct dry and rainy seasons. A continuous dry spell of more than 20 days (less than 5mm rainfall per day inclusive) which may damage the crops can occur once in a year. Long dry spells lasting more than 40 days which occur in such areas as India, the Philippines, Northern Australia and Thailand are seldom observed in Brunei. Rainfall of more than 50mm (2 inches) per day may follow a prolonged dry spell.

2 During more than ten months in a year, the monthly rainfall is likely to exceed 150mm (6 inches) and precipitation exceeding 250mm (10 inches) per month may occur in 5 out of 10 months.

3 Average monthly and yearly temperature tends to range from 27°C to 28°C (80°F-82.4°F) and does not fluctuate much. Daily fluctuations of temperature are in the range of 5°C (9°F) with the night temperature ranging from 22°C to 23°C (71.6°F-73.4°F).

4 There is generally a south wind in the morning and north wind in the afternoon. This

Table 1 Climate of Brunei Darussalam (tropical climate)

Negara Brunei Darussalam		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Mean temperature	Maximum	30.0	30.2	31.4	31.9	32.4	32.2	31.9	32.3	32.3	31.4	32.2	31.8	31.7
(°C)	Minimum	23.2	22.8	22.5	23.1	23.2	22.5	21.9	22.3	22.4	22.0	22.5	23.1	22.6
Mean relative humidity at 8:00 a. m. (%)		94.2	93.2	95.1	93.0	91.6	92.7	93.6	93.5	92.8	91.6	91.1	92.6	92.9
Total rainfall mm)		363.2	111.8	114.3	444.5	264.2	149.9	134.6	139.7	114.3	309.9	223.5	703.6	256.5

Temperature	1	2	3	4	5	6	7	8	9	10	11	12	Mean
Darwin	28.2	27.9	28.3	28.2	26.8	25.4	25.1	25.8	27.7	29.1	29.2	28.7	27.6
New Delhi	14.3	17.3	22.9	29.1	33.5	34.5	31.2	29.9	29.3	25.9	20.2	15.7	25.3
Manila	25.4	26.1	27.2	28.9	29.4	28.5	27.9	27.4	27.4	27.2	26.4	25.4	27.3
Bangkok	26.1	27.6	29.2	30.3	29.8	28.9	28.4	28.2	27.9	27.6	26.7	25.5	28.0

Humidity	1	2	3	4	5	6	7	8	9	10	11	12	Mean
Darwin	80	82	79	73	62	57	57	59	65	69	72	77	69
New Delhi	62	47	39	25	25	39	67	73	65	49	44	55	49
Manila	79	74	68	67	71	79	83	86	86	84	83	82	78
Bangkok	74	77	77	77	80	81	82	83	85	85	82	76	80

Rainfall	1	2	3	4	5	6	7	8	9	10	11	12	Total
Darwin	341	338	274	131	9	1	3	5	17	66	156	211	1,562
New Delhi	25	22	17	7	8	65	211	173	150	31	1	5	715
Manila	18	7	6	24	110	236	253	480	271	201	129	56	1,791
Bangkok	9	29	34	89	166	171	178	191	306	255	57	7	1,492

Brunei Statistical Yearbook .

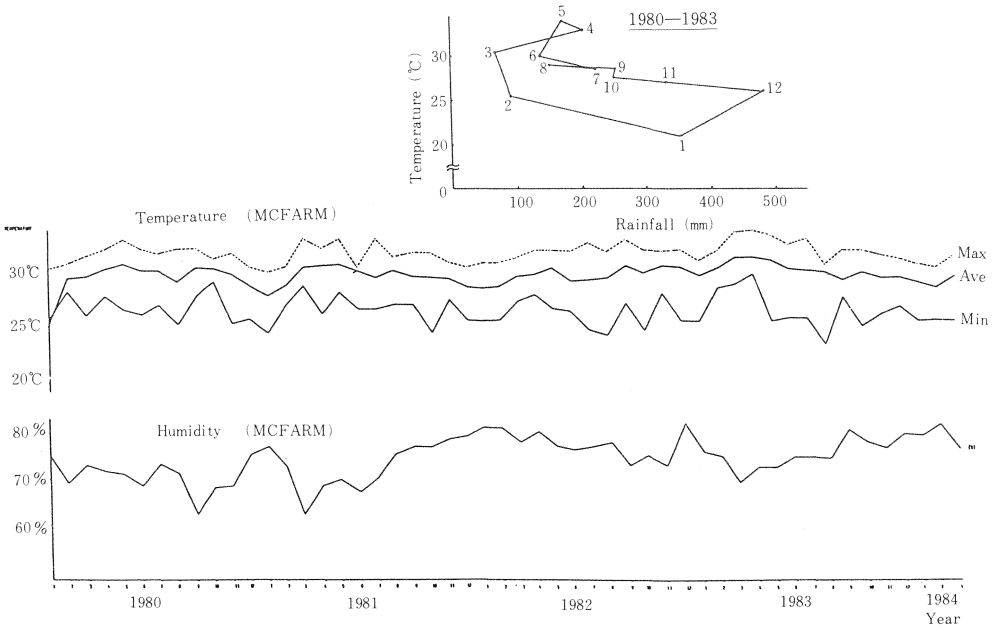
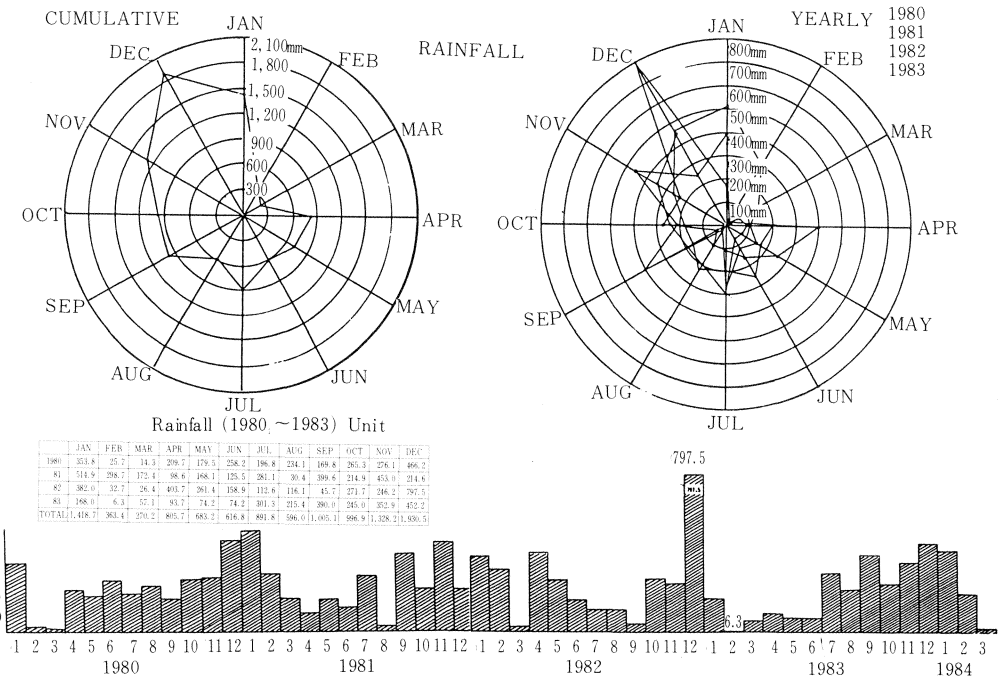


Fig. 2 Yearly changes in temperature and humidity in Brunei Darussalam.



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1980	353.8	25.7	14.3	209.7	179.5	258.2	196.8	234.1	169.8	265.3	276.1	466.2
81	514.9	298.7	172.4	98.6	188.1	125.5	261.1	30.4	399.6	214.9	453.0	214.6
82	382.0	32.7	26.4	403.7	261.4	158.9	112.6	116.1	45.7	271.7	246.2	787.5
83	168.0	6.3	52.1	93.7	74.2	74.2	301.3	215.4	396.0	245.0	352.9	472.2
TOTAL	1,418.7	363.4	270.2	805.7	683.2	616.8	891.8	596.0	1,005.1	996.9	1,328.2	1,930.5

Fig. 3 Yearly changes in rainfall in Brunei Darussalam.

pattern is constant throughout the year.

5 Wind velocity does not vary much and tends to be less than 4 m/s with occasional high velocity of more than 20m/s during storms lasting for only about half an hour.

6 Sunshine monthly mean hours number about 200 hr to 250 hr and are rather constant throught the year.

Under these conditions, the following development plan was adopted.

Meteorology

1 Since the risk of damage of pasture grass due to a long dry spell is negligible, priority should be given to the prevention of damage caused by excessive rainfall.

2 If the selected breeds of animals are tolerant to such an ambient temperature of 27° C-28°C, the risk of physical unfitness or outbreaks of diseases associated with the high temperature is rather small since daily changes in the temperature are minimal.

3 The risk of damage caused by strong wind is also negligible.

Soils

1 Within the top soil layer containing organic matter (A Layer) the A D Layer (A Layer with decomposing fallen leaves and a mixture of intact and decomposed plant tissues and the Al layer (containing a mixture of decomposed organic matter and clay affecting each other in physical and chemical reactions) are very thin and right beneath them, there are layers of Latosol with few nutrients.

2 The soil has been subjected to weathering and erosion and is very acid, which necessitates the application of lime.

3 At a depth of 30cm below the surface, there is a heavy clay layer which is impermeable and the level of ground water is very high. Rain water therefore cannot permeate into the sub-soil and tends to stagnate on the ground surface.

4 The soil does not hold water in its matrix and the water content is very much affected by the weather conditions.

5 In wet lowlands, the top soil of the A Layer tends to be thick, but the land is poorly drained, which is not suitable for agriculture development unless large scale drainage facilities are set up.

Farm development

1 Clearing of jungle and site preparation

Site preparation for pasture and grazing field can be done in either of the following ways.

a Natural topography method
b Improved topography method
c Contour terrace method

The selected site with an inclination of less than 8° did not require the adoption of either method b or c. The implementation of the latter two methods always involves the risk of erosion after clearing the land, hence the method a was adopted, which enabled to retain the natural and existing drainage conditions.

2 Ploughing

In an area where clearing had been completed, ploughing work was initiated by using a 3-disc plough. Small tree trunks of less than 7cm in diameter were easily crushed and automatically buried into the ground by disc ploughing. Larger trunks had to be removed manually and burnt.

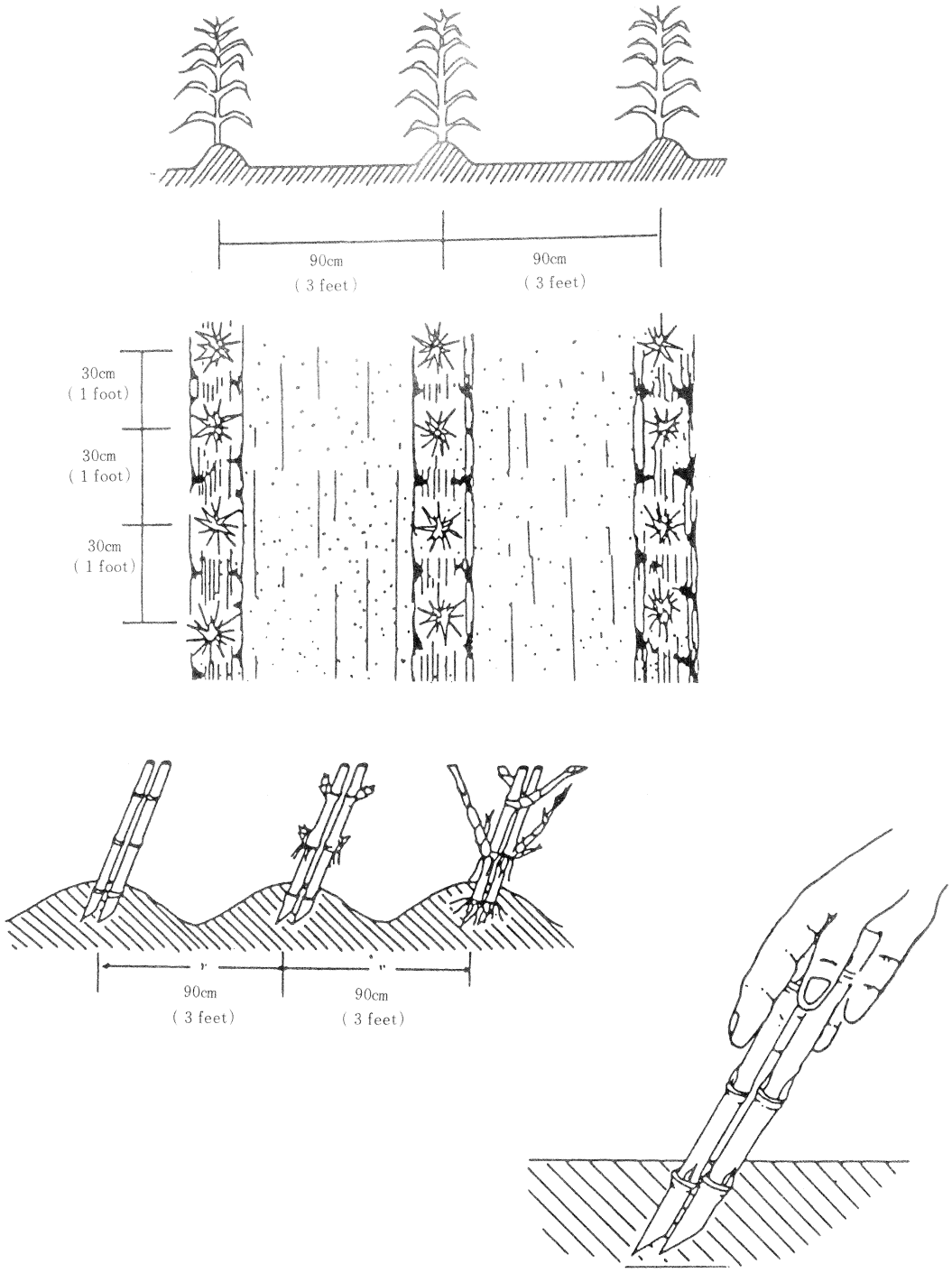


Fig. 4 Planting of Napier grass stem.

In the farm, a typical sublayer consists of litter with ferrous oxide or alumina heavy clay layer including kaolinitic clay. Since there is little possibility of having a layer of leaf mold which could be improved by ploughing and also since there was a potential risk of severe erosion if the heavy clay layer was exposed, the ploughing work was conducted only to a depth of about 20cm.

Due to the continuous effect of strong sunshine and heavy rain, the acidity of the surface layer is rather high, with pH values ranging from pH 3.7 to 4.2. Therefore, before the start of ploughing, 1 ton/acre of lime was applied resulting in the decrease of the acidity (pH above 4.5) to some extent.

Disc ploughing in flat areas was repeated two to three times whereas in slopy areas disc ploughing was performed once along the contour to avoid the risk of subsequent erosion.

In the Napier forage field, there were small creeks which had been filled due to inappropriate earthwork. This resulted in the erosion of the surface of the sloping area in the form of gullies on the ground surface associated with rainfall. To eliminate the risk of further erosion which would damage the Napier grass, logs or plants were placed along each 10m contour to control the surface water. The erosion process persisted for the first two years and later was gradually controlled.

3 Harrowing

In areas where ploughing had been completed, harrowing was started for crushing the soil and smaller vegetation and to level the top soil. At the same time, basal fertilizer was applied. Initial fertilizer design was:

N: 29 kg/acre; P: 88.5 kg/acre; K: 23.5 kg/acre; MgO: 4.4 kg/acre

At the end, a spike tooth harrow was used for finer crushing of soil and removal of residual vegetation.

4 Seeding

Thereafter, imported grass seeds from Australia were broadcasted. The following pasture grasses were used.

(1) Grass

Guinea grass (*Panicum maximum*)

Guinea grass was used as a pioneer grass on the newly established pasture but later it was replaced by some other grasses.

Signal grass (*Brachiaria decumbens*)

Signal grass has performed well at MCFARM on relatively dry and sloping areas. Signal grass, in a pure sward, responds to fertilizer nitrogen. It appears that Signal grass does not perform too well during a very wet period.

(2) Legumes

1 Stylo (*Stylosanthes guyanensis* syn. *S. gracilis*)

2 Centro (*Centrosema pubescens*)

Both Stylo and Centro did not perform well in the pasture and gradually disappeared. A part of legumes seemed to grow well under the shade and went into the jungle.

5 Planting of Napier grass

As a supplemental feed to cattle during the night, a forage field covering 30 acres was prepared to grow Napier grass (*Pennisetum purpureum*). This grass is native to tropical Africa, but has been grown in many other tropical countries. It is mainly suited to a coastal climate with an annual rainfall of over 1,000mm (40 inches).

Napier grass is a cane-like perennial grass with thick, strong stems which may reach a height of 3m (9 feet). It has an extensive and deep root system which confers good tolerance to dry conditions.

The main growth period is the summer when the temperature and humidity are high and little growth occurs during cooler months. Napier grass is best adapted to deep fertile soils and because of its extreme vigor draws heavily on soil nutrients.

Very high yields of forage have been recorded in Southeast Asia and in tropical regions.

Seeding is rare and rather difficult and Napier is generally established vegetatively by planting hard stem pieces bearing 3-4 nodes or joints after field preparation. Rain falling after planting leads to the improvement of the development of the root system. Classification of the various kinds of Napier grass is not well documented in Southeast Asia.

Annual production can amount to 60-80 ton/acre with eight harvests a year. Napier grass is well accepted by cattle but when it has grown too old and if the harvest is delayed for some reason, stems tend to harden and the quality deteriorates.

Since the effect of nitrogen fertilizer is very significant, application was as follows:

N: 48.3 kg/acre; P: 147.5 kg/acre; K: 39.2 kg/acre; MgO: 7.3 kg/acre

Napier stem planting was carried out manually in strip planting at intervals of 90cm (3 feet) between rows and 30cm (1 foot) between plants in a row, as indicated in Fig. 4.

Development of pasture field

Amongst the seeds of pasture plants belonging to the leguminous family which were broadcasted, Stylo started to germinate within about seven days after sowing. Centro started to germinate from the 14th day or so after seeding. However, it took a considerably longer time such as 30 days before the Guinea grass and Signal grass started to germinate.

Overall germination percentage was generally satisfactory and the grass grew quite rapidly. In about 90-day time, Guinea grass came to ear and the pasture field was completely covered with Guinea grass. In order to accelerate the growth of Signal grass and other leguminous pasture plants and to promote the tillering of Guinea grass itself, cutting by mower to roughly a 15cm height above the ground level was carried out. During the development period, growth of grasses was satisfactory and no outbreaks of insect pests nor diseases occurred. However, the growth of all grasses including Guinea grass on slopes or in areas where the subsoil was exposed was poor and the density of growth was low, because on sloping areas seeds as well as basal fertilizer and lime were all washed away due to rainfall.

In areas where the subsoil was exposed, some germination occurred but root development was hampered and subsequent growth was poor, resulting in the withering or low growth of the plants.

Development of Napier grass

In Napier grass germination from the nodes of all of the stems planted started about three days after planting and rooting started three to four days after planting. The plants grew to reach a height of more than 1.2m (4 feet) within 40 to 45 days and covered the field completely.

Since planting of Napier grass was planned at a rate of 0.65 acres per day and 50 days prior to the scheduled date of arrival of cattle (end of March, 1979), it was possible to harvest the grass at an appropriate height when cattle were delivered to the farm.

Yearly changes in growth of pasture grass are indicated in Fig. 5.

Amongst the grasses initially broadcasted, i. e. Guinea grass, Signal grass, Stylo, Centro and Puero, Guinea grass was dominant for about one year after the broadcasting of seeds. However Signal grass thereafter invaded the Guinea grass area to become dominant. This is probably because Guinea grass came to ear before cattle were introduced into the pasture and presumably because Guinea grass which is comparatively frail for pasture purpose, was

	kg/25m²
MAY 1981	2.8
JUN 〃	2.5
JUN 〃	3.6
AUG 〃	3.6
SEP 〃	2.0
OCT 〃	4.1
NOV 〃	4.3
DEC 〃	1.5
JAN 1982	2.1*
FEB 〃	2.7
MAR 〃	1.9
APR 〃	3.5
MAY 〃	4.7
JUN 〃	7.4
JUL 〃	8.0
AUG 〃	6.3
SEP 〃	2.9
OCT 〃	5.0
NOV 〃	8.0
DEC 〃	6.0
JAN 1983	5.8
FEB 〃	4.3
MAR 〃	2.5
APR 〃	4.5
MAY 〃	4.3
JUN 〃	3.5
JUL 〃	3.8
AUG 〃	5.2
SEP 〃	4.6
OCT 〃	4.3
NOV 〃	5.5
DEC 〃	3.7
JAN 1984	2.9

*ESTIMATED WEIGHT

Fig. 5 Yearly changes in grass production.

overwhelmed by the prostrate nature of Signal grass. Leguminous pasture grass was seen covering about 20% of the area in the initial stage. However following the decline of Guinea grass, propagation of leguminous grass decreased and the grass decayed and covered alout 5% of the pasture field.

The decline of leguminous pasture grass, may be due to the lack of growing point caused by cattle eating up the zone near the root of the grass where the short prostrate-type Signal grass overwhelmed the field. However, leguminous grasses actually grew quite thick outside the pasture fence, and by the time Guinea grass which is higher had grown thick, both Centro and Stylo grass failed to have the zone near the root eaten up by cattle and grew well.

Gully erosion

Gully erosion occurred at Block 1 at various places (Fig. 6). Due to the fact that the vegetation was mistakenly removed from the steep slope outside the farm area when the land was being cleared, rain water collected into the belt as it ran down the slope and rushed into the farm area eroding the water paths and leaving large gullies at various spots, hence the soil was washed away.

Gullies always developed upstream, becoming deeper and wider and branching off literally. Approximately five acres of the area were eventually covered by gullies.

In order to prevent the development of gullies, intercepting ditches were constructed at the top and bottom of the steep slopes outside the farm area to divert the flow of water off the gullies to rivers at the lower level. Contour strips of Napier grass and tropical Kudzu

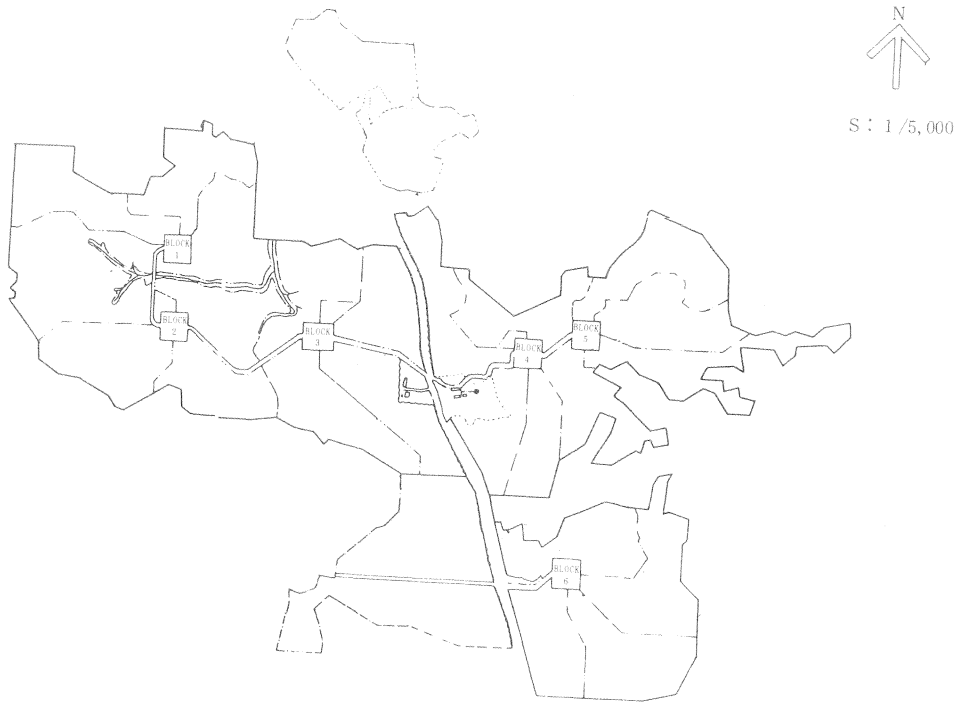


Fig. 6 MCFARM site map.

were also made. With these measures, further expansion of gullies was prevented for about three years.

Succession of vegetation

Regressive succession of vegetation was found to occur at Blocks 5 and 6 one year after the onset of grazing.

In these two blocks, after land development, sowing took place prematurely before enough ploughing was carried out-as little as once instead of four times in the other blocks. Germination of weeds also occurred along with pasture grass germination, and although the pasture grass once predominated in about three-month time, growth of grass was poor because of the coarse ploughing and at the time grazing started, the pressure became too strong at various spots, leading to the regressive succession of vegetation. Particularly around water drinking areas or along the cattle paths *Cyperus pilosus* Vahl-referred to as animal resting-place vegetation-started to proliferate and small shrubs appeared. As a result, the animals ate selectively the pasture grass and this type of vegetation continued to proliferate.

Palatability of various shrubs is poor and since hardly any eating or stamping down can be expected on such shrubs, they prevail in the area and proliferate. Partial reploughing and reseeding were carried out to prevent such succession. However as soon as the pasture grass started to grow cattle resumed the selective eating and invasion of shrubs took place oven faster.

In April 1980, stabilization measures were taken by closing Block 5-Area 3 and Block 6-Area 2, in removing the shrubs and reploughing the total area.

Succession of vegetation to *Zoysia* type pasture by overgrazing was observed from the

time when Block 5 was converted into exclusive use for rearing heifers in February 1982 and the number of head grazing exceeded 127 unit (about 2.5 head/acre). This phenomenon is ascribed to the fact that the growing point of Signal grass is located above-ground and cattle ate everything down to the growing point due to overgrazing whereas *Zoysia* type grass continued to reproduce as its growing point is below the soil level.

Unlike shrubs or non-edible grass, sward pasture, in spite of a low output, is available as feed. In this regard, renovation of pasture field was carried out mainly by reseeding *Zoysia* type grass after harrowing. However, speed of invasion by shrubs and non-edible grass into the *Zoysia* type pasture is fast. This is because, shrubs and non-edible grass are taller than sward and their photosynthetic efficiency is higher, hence this profuse growth.

Removal of shrubs or non-edible grass by burning, uprooting or use of herbicides is difficult once they invade the pasture. Burning, whereby phanerophytes such as trees which have dormant buds above ground are destroyed does not damage hemicryptophytes whose dormant buds are near the ground surface. Burning thus prevents the transformation into forest vegetation. Meanwhile, since burning decreases the moisture holding capacity of soil, caution must be exercised to avoid the destruction of the pasture field.

Use of herbicides against weeds and shrubs is not effective except for 2-4-5. T to some extent. Removal of roots which is a reliable method to prevent the propagation of shrubs is laborious and must be practiced before bushes and shrubs propagate over large areas. At MCFARM, the field is observed in order to remove young shrubs.

Interval of rotation grazing

The interval of rotation normally depends on the seasonal fluctuations in the growth capacity of grass. However in Brunei Darussalam, there is no distinct seasonality and no stable pattern of weather change, hence it is difficult to determine the chronological pattern of growth capacity of grasses.

At the initial stage, grazing interval was fixed to one week, in allowing three weeks for the grass to grow without grazing, and one herd was rotated in four areas. It was considered that with this interval the cattle would receive enough grass in such a period as to enable grass to grow, hence maximizing the amount of edible feed. In a high temperature and humidity environment, the stems did not grow into sward and it was considered that it would be difficult to increase the density of grass. Therefore, a 5-day interval was adopted for several months but again sward development was insufficient and in some areas the grass became too old and the stems underwent lignification. Again as a trial, later a 10-day interval of grazing was adopted for each of the four areas, from April 1981. This resulted in the elimination of the seedlings and grass height reached about 30cm (1 foot) instead of 50-60cm (2 feet) before the start of grazing and 8cm (3 inches) after a 10 day-period of grazing. The increase of density however was rather slow and to stimulate it harrowing and additional seeding were performed. As a result, the density of grass increased gradually.

Interval of Napier grass harvest

The interval of harvest of 22 acres of Napier grass was fixed to 45 days, 0.5 acre/day for 45 days for each 0.5 acre, enabling an average of 8.1 harvests a year. The annual output of Napier grass at the initial stage was 86 ton/acre. Later, during the rainy days the part of Napier field, which was located either in an undrained area or hilly area was found to be unsuitable for operations such as fertilizer application, harvesting, weeding and hauling, thus making the management of the Napier field very difficult. This resulted in a prolonged harvest rotation of over 45 days and earing was observed, with a lower productivity of Napier grass. These areas were eventually abandoned and the area planted to Napier grass

Table 2 Relation of plant length and cutting volume of Napier grass

Weight (X)	Height (Y)	Weight (X)	Height (Y)	Weight (X)	Height (Y)
3,512	190	2,865	200	9,412	200
4,495	155	9,912	215	6,602	210
3,287	135	13,918	240	5,844	185
8,577	220	3,174	185	5,872	220
6,271	185	3,174	195	6,040	205
10,681	230	6,311	185	8,294	195
4,636	235	15,172	265	7,867	190
7,923	220	9,918	205	4,733	170
8,415	195	8,710	220	6,716	185
8,294	190	6,940	220	2,809	165
8,496	210	11,660	220	14,565	200
7,282	210	8,963	235	8,401	245
9,508	240	8,148	210	12,980	235
1,236	155	8,007	235	8,794	235
4,733	180	8,294	205	17,397	235
7,458	175	7,687	190	20,027	220
7,808	215	6,237	205	5,759	200
3,708	175	10,115	225	14,848	235
4,248	220	7,164	245	14,568	235
7,444	195	6,462	225	10,519	220
9,022	185	12,138	210	4,495	205
9,080	215	11,126	215	8,901	230
3,708	225	8,148	210	4,860	145
3,174	225	6,883	225	5,664	140
3,849	245	7,024	240	11,531	195
3,287	220	7,192	225	8,213	190
2,908	195	13,877	245	7,970	200
3,512	175	6,940	215		
$d_f=81$		$t=5.^{142}$	$P<0.001$		

Weight: kg/acre/harvest (45 -day interval
Height: cm

amounted to 16.56 acres with a daily harvest of 0.368 acre as one unit area for 45 units with 45-day interval (Table 2). Growth of Napier grass was closely related with the amount of rainfall (Table 3).

Fertilizers

1 Fertilizer application to the pasture field

Top dressing of pasture must be designed in taking account of the need for applying the optimum level of fertilizer including the three major elements to produce a certain amount of grass and the standard level of application of fertilizer for the same crop in neighbouring farms.

In the case of MCFARM, the experience gained at Jerudong Luahan agricultural stations, and the general guidelines for fertilization recommended by Dr. K. Mitsui (Livestock Research Center, Ministry of Agriculture, Forestry and Fisheries, Japan) were applied as a

Table 3 Length of Napier grass and amount of rainfall (analysis of variance)

Item	0—100 (mm)		100—350 (mm)		over 350 (mm)	
Plant height	210	195(cm)	230	240(cm)	200	220(cm)
	135	180	235	240	240	175
	135	200	250	235	175	150
	135		240	235	130	160
	135		230	215	210	155
	100		240	225	205	240
	190		210	245	230	205
	120		230	235	215	210
	150		220	230	235	220
	145		230	200	220	200
	130		210	175	200	215
	125		220	200	180	205
	120		215	230	195	230
	170		220	250	235	210
	160		225	245	145	210
	150		200	225	140	210
	165		200	220	195	200
	165		210	245	190	155
	155		210	200	165	180
	160		210	205	195	170
	165		210	225	205	
	155		220	245	200	
	170		220	235	195	
	170		225	235	190	
	180		225	200	190	
Total height	4,370		11,170		8,800	
Plant number	28		50		45	
Mean height	156.0		223.4		195.5	
	Variance ratio		$F^2_{120}=75.^{87}$		$P<0.001$(Significance)	

basis for determining the amount of fertilizer required, in taking into account the nutrient conditions of the soil at MCFARM and potential loss caused by heavy rainfall.

Initially top dressing was as follows:

Fertilizer (top dressing) on pasture

Elements	kg/acre/year
N	151.0
P	65.5
K	91.0
Mg	26.3

Top dressing was performed by using a broadcaster at each of the four areas at the time when a herd was rotated to the next area.

Under these conditions legumes in the pasture did not grow well for the following reasons:

a phosphorus requirement of legumes was high

b the absorption rate of phosphorus by legumes was low, and

. c the low rate of potassium application resulted in insufficient development of legumes.

As a result, in May 1981, fertilizer levels were modified as follows:

Elements	kg/acre/year
N	105.5
P	70.0
K	96.5
Mg	18.4

This modification did not result in any improvement of the growth of legumes and a decrease in grass production as well as in legume growth was recorded.

In April 1982, top dressing was modified as indicated below:

N: 130.0kg; P: 65.0kg; K: 92.0kg and Mg: 11.0kg

The amount of Mg applied was reduced since no symptoms of grass tetany due to Mg deficiency had been observed.

2 Top dressing in the field with Napier grass

Top dressing consisted of N: 371kg; P: 123kg; K: 204kg; Mg: 67kg, each per acre. In 1981, Mg application was slightly lowered to 60kg.

Discussion

Siregar, M. E. (Indonesia): Do you encounter any problems with ectoparasites and do you observe any nutrient deficiencies?

Answer: Yes, we observe ticks which create wounds on cattle. Magnesium deficiency is a problem and grass tetany has been observed.

Cocks, P. S. (ICARDA): Is the farm making good profit?

Answer: No, I am afraid.