SOILS AND FERTILIZERS FOR SOWN PASTURES IN MALAYSIA

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SUMMARY

Development of the dairy and beef cattle industries in Malaysia depends largely on the successful establishment of improved pastures. In pasture management, soil fertility problems are mainly those associated with nutrient supply. Improved permanent pastures have been established on a number of different soils on which deficiencies of phosphorus, potassium, molybdenum and copper are likely. In legume based pastures on newly cleared forest soils, nitrogen may not be necessary for establishment or maintenance. Considerable savings in fertilizer costs are possible by using legumes to provide the nitrogen component. At 1976 *prices, fertilizers for maintaining nitrogen-fertilized pastures and 'cut and carry' grass fodders cost three and six times as much respectively as for legume based pastures.*

INTRODUCTION

In the context of current plans for economic development in Malaysia, the expansion and growth of the livestock industry is considered to be crucial. The non-ruminant component (poultry and pigs) has developed rapidly while the ruminant section (cattle and goats) has lagged behind.

Beef contributes only about four percent and dairy products seven percent to the consumption of animal protein in peninsular Malaysia; poultry meat and eggs contribute nearly 70 percent and pig meat 17 percent. The estimated *per capita* consumption of beef in 1975 was 3.09 kg and the demand in 1985 has been projected at 3.29 kg (Mahendranathan 1975). Development of the beef cattle industry envisaged during the next decade will depend largely on the successful establishment of improved pastures which can provide a continuous supply of feed with minimal overhead cost (Kerridge *et al.* 1974). Investigations at the Malaysian Agricultural Research and Development Institute (MARDI), the programs of the Veterinary Services, and the countrywide development projects of the Livestock Development Board (MAJUTERNAK) are being directed to the establishment and maintenance of improved pastures for the anticipated expansion of the beef and dairy cattle populations.

In Malaysia there is little conservation of pasture herbage. There has been some production of dried grass in meal and pellet form (McMichael *et al.* 1974), but grass is used mainly as fresh herbage for grazing or 'cut and carry' feeding. In the management of pastures, soil fertility problems encountered are largely those associated with nutrient supply, and fertilizer programs are of considerable importance.

SOILS FOR SOWN PASTURES

Native grassland in Malaysia

None of the main types of natural grassland is found in Malaysia as a stable climatic climax vegetation. This is perhaps the reason why grass has not been extensively used for livestock production and reference to grassland is very scanty in the literature. Early work on the productivity of pastures in Malaysia has been reported by Camoens (1972). However neither the land capability classification of Panton (1966) nor the soil suitability classification of Wong (1966) refer to grassland. In discussing the land use of West Malaysia in 1966, Wong (1971) mapped 'improved permanent pasture' and 'grassland and scrub grassland'.

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'Improved permanent pasture', referred to areas where experimental pastures had been sown. There are at present about 6000 ha of permanent pastures in peninsular Malaysia all of which are located on well-drained, gently sloping (0–6°), low hills.

Nearly 400,000 ha of 'grassland and scrub grassland' have been mapped throughout peninsular Malaysia but none of it is in contiguous large tracts. The main constituent is 'lalang' (*Imperata cylindrica*) often mixed with low bushes and ferns (*Gleichenia* spp.). In the east coast, much of the 'grassland and scrub grassland' is on sandy beach ridges. On the west, it is located in the upland region as abandoned allotments on the edges of developed land. Some abandoned areas of shifting cultivation are also under grass.

Mahendranathan (1974) estimated about 38,000 ha of gazetted grazing reserves in peninsular Malaysia, but these are mostly on poor soils, their productivity is low, and they have deteriorated through neglect.

There is considerable scope for developing pastures, integrated as an intercrop, in plantations with coconut, oil palm, rubber and fruit trees. Ng (1969) refers to the possibility of combining pastures with livestock under coconut plantations on the east coast beach sands ('bris' soils).

Malaysian pasture soils

Pastures have been established on all types of soils. In fact, the less fertile soils that are marginal for arable or plantation crops are usually used for sown pastures. Fertility problems encountered are mainly those associated with nutrient deficiencies or toxicities and these can be corrected by proper management. Soil physical properties such as hard pans and poor drainage can limit pasture growth. Hard pans can be broken by tillage and poor drainage corrected by drains. Poorly drained heavy clay soils are often unsuitable for grazed pastures.

Improved permanent pastures have been established on (a) *Ultisols* of the Rengam, Serdang, Durian and Bungor series (b) *Oxisols* of the Munchong, Jerangau, Malacca and Kuantan series (c) Sandy *Entisols* ('bris' soils) of the east coast, and of the Holyrood series.

Analytical data on some of these soils is given in Table 1. The soils are all acidic, varying in texture from sandy (Rudua and Serdang series) to clayey (Kuantan series). Their carbon and nitrogen contents are generally low. They have low total phosphorus (except for the Kuantan series) while phosphorus fixation is relatively large as indicated by the low NaOH-soluble P values. Cation exchange capacities vary between about 8 to 17 meq percent while the amounts of exchangeable bases are small; exchangeable K is usually less than the 0.2 meq K 100 g^{-1} soil which is the critical value below which potassium deficiency can result. Kerridge and Tham (1974) reported a universal deficiency to phosphorus in establishing legumes and grasses and suggested that deficiencies to potassium, molybdenums and copper may also occur.

FERTILIZERS FOR PASTURES

Principles of pasture fertilization

Some differences in the nature of pastures in contrast to field crops will affect the choice of fertilizer program. Pastures are continuously grazed or cut for stall feeding at frequent intervals of four to six weeks whereas most arable crops are harvested after three to four months and replanted. Tropical grasses have high photosynthetic rates and dry matter production is therefore higher than in dicotyledenous field crops whose photosynthetic rates are lower. In legume based pastures, much of the nitrogen can be supplied by the legume component whereas nitrogen in arable cropping is usually given as nitrogenous fertilizer.

Fertilizer programs depend on the system of pasture utilization, whether for fodder as fresh herbage, hay, dried grass and silage, or for grazing. Pasture used for cut

TABLE 1

Analytical data on some Malaysian soils

Soil Series	pH	Texture clay	silt %	sand	C %	N %	P total NaOH-sol. ppm		Exch. cations Ca	Mg meq	K 100 g^{-1}	CEC	BS %
Rengam	3·5 – 5·1	38	8	54	1·45	0·12	113	36	0·22	0·33	0·12	8·3	9
Serdang	3·3 – 5·4	25	10	65	0·94	0·08	109	30	0·22	0·27	0·08	8·0	8
Durian	3·9 – 4·9	55	20	25	1·48	0·13	80	37	0·27	0·33	0·13	12·7	6
Bungor	3·7 – 5·4	33	14	53	0·97	0·09	165	44	0·33	0·31	0·09	8·5	10
Munchong	3·9 – 5·3	44	16	40	1·22	0·11	156	53	0·32	0·38	0·13	11·6	8
Jerangau	3·4 – 5·1	48	6	46	1·85	0·19	281	64	0·29	0·25	0·11	11·9	7
Malacca	3·7 – 4·9	58	11	31	1·51	0·13	207	67	0·34	0·34	0·13	12·0	7
Kuantan	3·0 – 5·4	70	14	16	2·40	0·18	581	185	0·41	0·39	0·09	17·2	6
Holyrood	3·5 – 5·4	23	5	72	1·51	0·13	370	75	0·35	0·20	0·07	9·0	8
Rudua	4·2 – 4·8	0	0	100	0·52	0·03	—	76	0·05	0·45	0·03	4·6	15

fodder is fertilized in the same way as arable crops; adequate nutrients must be supplied to make up for those removed in the herbage and for other losses, mainly by leaching.

Fertilizer application on grazed pasture depends on the methods of management employed. The nature and extent of the legume component will determine the amounts of nitrogen used. More nutrients are needed when animal products such as milk are sold off the farm. Grazing animals return some nutrients in the form of dung and urine; beef cattle return most of the phosphorus and potassium in their urine and dung, whereas with dairy cows appreciable removal losses of these elements can occur.

Fertilizer is necessary for the establishment as well as for maintenance of sown pastures.

Sources of nutrients

Among the chemical fertilizers used to supply nitrogen for pastures are ammonium sulphate, urea, ammonium nitrate, and calcium ammonium nitrate. Ammonium sulphate supplies not only nitrogen but also sulphur and is to be preferred whenever sulphur deficiency is expected. Continuous addition of ammonium sulphate induces acidity and lime will have to be used to correct this. Less lime is needed if urea is used but losses of nitrogen due to volatilization of ammonia can be serious under hot humid Malaysian climatic conditions. Perhaps the best nitrogenous fertilizers for pastures are ammonium nitrate and calcium ammonium nitrate, which supply N both as NH_4 and NO_3. But in Malaysia, the unit cost of nitrogen in ammonium nitrate and in calcium ammonium nitrate (M$1.5) is more than in urea (M$0.8) or even in ammonium sulphate (M$1.4) at 1976 fertilizer prices (Table 2).

Christmas Island rock phosphate (CIRP) is the cheapest source of phosphorus available, containing 15% P ,most of which is however water insoluble, and 35% Ca (Table 2). Triple superphosphate (20% P and 14% Ca) contains nearly all of its phosphate in the water-soluble form but is more than twice as costly per ton (Table 2). On acid soils with a high phosphorus fixing capacity the water soluble phosphate in triple superphosphate will be reverted to insoluble forms. It would perhaps be advisable to use triple superphosphate, or a mixture of triple and CIRP for establishment of pastures, and CIRP for maintenance dressings.

Muriate of potash is the least expensive form of potassium available, containing 50% K. Sulphate of potash-magnesia supplies both Mg and S in addition to K but its K content is only 22% and the unit cost of K in it (M$1.4) is more than in muriate of potash (M$0.6).

Farmyard manure and poultry manure are valuable materials for fertilizing pastures and should be used whenever available. The utilization of chemical fertilizers is enhanced when applied together with some organic matter (Camoens 1972). One ton of average FYM contains approximately the same amounts of nutrients as 100 kg of fertilizer grading 10–6–10. As FYM is generally low in P it should be supplemented with triple superphosphate to avoid nutrient imbalance. One ton of poultry manure usually contains about the same amounts of nutrients as 100 kg of fertilizer grading 20–16–10. It is relatively high in nitrogen and phosphorus but low in potassium and should therefore be supplemented with potassium. Camoens (1972) found poultry manure to be better than cow dung for Napier grass on a Holyrood series sandy loam.

Rates and times of application

Crop response data from fertilizer trials on different types of soil would ideally be needed to make recommendations on rates of fertilizer application. Fertilizer costs and expected prices of livestock products sold, the pasture plants grown, soil moisture regimes, and grazing patterns or utilization management of the pasture would also influence the amount of fertilizer that should be applied.

Generally, nitrogen is best given in the form of split applications after every cutting or grazing. For most tropical grasses 25–50 kg N ha^{-1} could be applied under

TABLE 2

Analyses of some inorganic fertilizers used in Malaysia

Fertilizer	N	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B	Mo	Price/metric ton M$
NITROGEN SOURCES													
Ammonium sulphate	21	—	—	—	—	24	—	—	—	—	—	—	290
Ammonium nitrate (Nitro-26)	26	—	—	—	—	—	—	—	—	—	—	—	400
Ammonium sulphate nitrate	26	—	—	—	—	12	—	—	—	—	—	—	380
Calcium ammonium nitrate	26	—	—	14	—	—	—	—	—	—	—	—	400
Ammonium chloride	25	—	—	—	—	—	—	—	—	—	—	—	350
Urea	46	—	—	—	—	—	—	—	—	—	—	—	390
Potassium nitrate (Saltpetre)	13	—	36	—	—	—	—	—	—	—	—	—	700
PHOSPHORUS SOURCES													
Di-ammonium phosphate	16	9	—	—	—	—	—	—	—	—	—	—	700
Ordinary superphosphate	—	8	—	20	—	14	—	—	—	—	—	—	250
Triple superphosphate	—	20	—	14	—	—	—	—	—	—	—	—	550
Rock phosphate (CIRP)	—	15	—	35	—	—	—	—	—	—	—	—	260
Basic slag	—	9	—	35	5	—	—	—	—	—	—	—	50
POTASSIUM SOURCES													
Muriate of potash	—	—	50	—	—	—	—	—	—	—	—	—	300
Sulphate of potash	—	—	42	—	—	18	—	—	—	—	—	—	650
Sulphate of potash magnesia	—	—	22	—	9	9	—	—	—	—	—	—	305
CALCIUM SOURCES													
Limestone dust	—	—	—	36	2	—	—	—	—	—	—	—	40
Calcium carbonate fert. grade	—	—	—	39	—	—	—	—	—	—	—	—	40
MAGNESIUM SOURCES													
Ground magnesium limestone	—	—	—	44	12	—	—	—	—	—	—	—	50
Kieserite	—	—	—	—	16	23	—	—	—	—	—	—	350
Epsom salt	—	—	—	—	10	13	—	—	—	—	—	—	700
SULPHUR SOURCES													
Gypsum	—	—	—	23	—	18	—	—	—	—	—	—	—
MICRONUTRIENT SOURCES													
Ferrous sulphate	—	—	—	—	—	14	24	—	—	—	—	—	450
Manganese sulphate	—	—	—	—	—	15	—	25	—	—	—	—	1000
Copper sulphate	—	—	—	—	—	12	—	—	25	—	—	—	500
Zinc sulphate	—	—	—	—	—	11	—	—	—	23	—	—	1500
High grade borate	—	—	—	—	—	—	—	—	—	—	10	—	800
Sodium molybdate	—	—	—	—	—	—	—	—	—	—	—	39	M$18/- per kg

2·45 M$ = 1 A$

favourable rainfall conditions. Slightly higher rates could be used for fodder grasses such as Napier.

Phosphorus application at establishment of pastures may be 70–80 kg P ha^{-1} as CIRP and 20–30 kg P ha^{-1} as triple superphosphate, in a single application before seeding or planting. For maintenance, 30–60 kg P ha^{-1} as CIRP once a year is recommended for grazed pastures, with the higher value of 60 kg P ha^{-1} for cut-and-carry grass fodders.

More potassium fertilizer is needed when forage is cut and fed than when pastures are grazed. It is best to do a soil test and apply potassium fertilizer when the K content of the soil is low, less than about 0.2 meq K/100 g soil. If too much potassium is applied at the same time 'luxury uptake' may occur and consequently a reduced intake, as well as enhanced leaching of Ca, Mg and Na. It may therefore be better to apply potassium in split dressings with the nitrogen.

Methods of application

In establishing grassland best results are obtained by placing phosphate fertilizer in a band five to ten cm below and somewhat to the side of the seed. Broadcasting fertilizer encourages weed growth and greater phosphate reversion in acid soils with much iron and aluminium. Rock phosphate may however be worked into the soil

TABLE 3

Cost of fertilizer for sown pastures

Type of Grassland	Nutrient	Fertilizer	Establishment Rate kg ha^{-1}	Establishment Cost ha^{-1}* M$	Maintenance Rate kg ha^{-1}	Maintenance Cost ha^{-1}* M$
I Grass/Legume Pasture	N	—	—	—	—	—
	P	TSP	20P	55	—	—
		CIRP	70–90P	139	30–60P	78
	K	MP	50–75K	38	50–75K	38
	Ca/Mg	DL	200DL	10	—	—
	Mo		100 g Mo	5		
		Cost per ha		247		116
		Cost per acre		100		47
II Grass Pasture	N	Urea	50N	42	300N	252
	P	as for I above		194 as for I above		78
	K	,,		38	75–100K	52
	Ca/Mg	,,		10 as for I above		—
		Cost per ha		284		382
		Cost per acre		115		155
III Grass Fodder 'Cut and Carry'	N	as for II above		42 up to 600N		509
	P	as for I above		194 up to 60P		104
	K	,,		38 up to 200K		120
	Ca/Mg	,,		10	—	—
		Cost per ha		284		733
		Cost per acre		115		297

Summary of costs per acre	Establishment M$	Maintenance M$
Grass/Legume Pasture	100	47
Grass Pasture	115	155
Grass Fodder	115	297

TSP = triple superphosphate, CIRP = Christmas Island rock phosphate
MP = muriate of potash DL = dolomitic limestone
*Cost of average application.

superficially when it is disc harrowed before sowing. Superphosphate should be drilled in together with the seed. Maintenance applications can only be applied to the surface.

Cost of fertilizer

Fertilizer prices in 1976 are generally 30–40 percent less than they were in 1975. Even so, fertilizers constitute a major proportion of the costs involved in establishing and maintaining sown pastures. Table 3 gives estimated fertilizer costs for the establishment and maintenance of pastures in Malaysia, based on 1976 fertilizer prices. Where a range of fertilizer rates is recommended, fertilizer cost has been calculated on the average rate.

Nitrogen has been omitted from recommendations for establishing and maintaining grass/legume pastures; in some instances, however, 20 kg N ha^{-1} may be used in establishing grass/legume swards. Some triple superphosphate could be used as a starter for all types of grassland but the cheaper rock phosphate is just as effective for annual maintenance dressings.

Considerable savings in fertilizer costs could be affected by using legumes to provide the nitrogen component. At 1976 prices, fertilizer applications for maintaining grass/legume pastures cost about one-third that for nitrogen fertilized grass pastures, and about one-sixth that for maintaining grassland for cut and carry feeding. When nitrogenous fertilizers cost more in 1975, the respective costs were one-fourth and one-eighth respectively.

However, carrying capacity and animal production levels per hectare are higher on nitrogen fertilized pastures. Further research is required to compare animal production on nitrogen fertilized and legume based pastures so that economies of production can be better compared.

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