UNIVERSITI PUTRA MALAYSIA

UTILIZATION OF ENERGY AND NITROGEN OF SETARIA SPHACELATA VAR. SPLENDIDA BASED DIETS BY DAIRY BULLS

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by

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A thesis submitted in fulfilment of the
requirements for the degree of Doctor of Philosophy
in the Faculty of Veterinary Medicine and Animal Science
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Dedicated to the memory of my late father and father-in-law

Mamat @ Muhammad and Haji Othman

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$B.W^{0.75}$	=	metabolic body weight
cm	=	centimeter
d	=	day
g	=	gram
h	=	hour
ha	=	hectare
hd	=	head
kg	=	kilogram
l	=	liter
MJ	=	mega joule
ml	=	mili liter
mm	=	milimeter
S.E	=	standard error
yr	=	year

An abstract of the thesis presented to the Senate of Universiti Pertanian Malaysia in fulfilment of the requirements for the Degree of Doctor of Philosophy

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MUSTAPHA BIN MAMAT

August 1987

Supervisor : Professor Dr. Mohd Mahyuddin bin Dahan

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Faculty : Veterinary Medicine and Animal Science

Three experiments were conducted at the Dairy Farm, Department of Animal Sciences, Universiti Pertanian Malaysia, Serdang, using four cross-bred dairy bulls, Jersey ♂ X Local Indian Dairy ♀ . The main objective of the study was to evaluate the effects of nitrogen fertilization and supplementation with urea and leucaena on the nutritive value and utilization of Setaria sphacelata var. splendida in cattle. The indices measured included rumen degradability, *in vivo* digestibility, feed intake and the concentration of ammonia-N in the rumen liqour. In the balance studies, nitrogen intake and nitrogen balance were determined.

The results of Experiment I showed that the yields of dry matter and nitrogen of the fertilized were higher than those of

the unfertilized forages, but the response (kg per kg nitrogen applied) in both dry matter and nitrogen was decreasing with increasing nitrogen fertilization. The highest response in dry matter was recorded at 26.6 kg/kg N applied; while that for crude protein was 4.0 kg/kg N applied. The highest nitrogen recovery was found to be 64.2 kg N/100 kg applied. These were achieved at the fertilization rate of 250 kg N/ha per year.

In Experiment II, the nutritional value of the grass forage fertilized at 0, 250, 500 and 750 kg N/ha per year, which constituted Treatments I, II, III and IV, respectively was studied. There was an increase in intake and digestibility of dry matter as the rate of nitrogen fertilization increased from 0 to 250 kg/ha per year. However, as the fertilizer rate was increased to either 500 or 750 kg/ha per year there was no further increase in the above two parameters, although crude protein content had increased from 10 to 12.8 g/100 g dry matter. The highest intake, 3.94 kg DM/hd per day was recorded for Treatment II. The results of the nitrogen balance studies showed that the balance for both Treatments III (9.68 g/hd per day) and IV (10.24 g/hd per day) were lower than that for Treatment II (13.4 g/hd per day). This finding indicated that while the efficiency of nitrogen utilization by dairy bulls increased significantly with nitrogen application up to 250 kg N/ha per year, further increase in the fertilizer rate did not significantly improve the efficiency. In the study it was also found that the mean ammonia-N concentration produced in the rumen liqour varied from 63.1 to 136.6 mg/l for forages at 0 and 700 kg N/ha per year, respectively.

In Experiment III the intake and digestibility of dry matter for bulls supplemented with leucaena, at 10 (Treatment III) and 30 (Treatment IV) g/100 g dry matter, were higher than those for bulls without leucaena (Treatment I - fertilized grass alone and Treatment II - fertilized grass plus urea molasses). Also, both these leucaena supplemented diets gave higher digestible energy intakes and nitrogen retention than diets without leucaena. However, digestible energy intake for diets incorporated with 30 g leucaena was greater than that with 10 g leucaena per 100 g dry matter. The concentration of ammonia-N produced when supplemented with leucaena was higher than that with grass forage alone but was lower than that supplemented with urea.

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PENGGUNAAN TENAGA DAN NITROGEN RANSUM BERASASKAN <u>SETARIA SPHACELATA</u> VAR. SPLENDIDA OLEH LEMBU TENUSU JANTAN

oleh

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Penyelia : Prof. Dr. Mohd. Mahyuddin bin Dahan

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Tiga eksperimen telah dijalankan di Ladang Tenusu, Jabatan Sains Peternakan, Universiti Pertanian Malaysia dengan menggunakan empat ekor lembu tenusu jantan jenis kacukan Jersey ♂ X Local Indian Dairy ♀. Objektib utama studi ini ialah mengkaji kesan-kesan pembajaan nitrogen dan makanan tambahan urea dan leucaena keatas nilai pemakanan dan penggunaan foraj <u>Setaria sphacelata</u> var. splendida dalam haiwan. Indeks yang diukur termasuk degradabiliti dalam rumen, nilai cerna <u>in vivo</u>, pengambilan makanan dan konsentrasi nitrogen-amonia dalam cairan rumen. Dalam kajian keseimbangan, nilai pengambilan nitrogen dan jumlah retensi nitrogen telah ditentukan.

Keputusan Eksperimen I menunjukkan hasil bahan kering dan hasil nitrogen bagi foraj berbaja nitrogen lebih tinggi daripada

foraj tanpa nitrogen, tetapi respons (kg bagi setiap kg nitrogen ditabur) bagi kedua-dua hasil bahan kering dan hasil nitrogen adalah didapati berkurang dengan meningkatnya kadar pembajaan nitrogen. Respons tertinggi hasil bahan kering telah dicatatkan pada tahap 26.6 kg bagi setiap kg N ditabur, manakala bagi protin kasar pula adalah 4.0 kg bagi setiap kg N ditabur. Pulangan balik nitrogen tertinggi ialah 64.2 kg bagi setiap kg N ditabur. Kesemua ini didapati pada tahap kadar pembajaan nitrogen 250 kg sehektar setahun.

Dalam Eksperimen II, nilai pemakanan rumput itu yang telah di tabur dengan 0, 250, 500 dan 750 kg N sehektar setahun, yang dikenal masing-masingnya sebagai Rawatan I, II, III dan IV telah dikaji. Penambahan nyata telah didapati dalam nilai pengambilan dan nilai cerna bahan kering apabila kadar pembajaan nitrogen ditambah dari 0 kepada 250 kg sehektar setahun. Tetapi apabila kadar pembajaan meningkat kepada samaada 500 atau 750 kg sehektar setahun didapati tidak ada penambahan dalam kedua-dua parameter tersebut walaupun kandungan protin kasar telah meningkat secara terus dari 10 kepada 12.8 g bagi setiap 100 g bahan kering. Pengambilan tertingi yang dicatatkan, 3.98 kg bahan kering seekor sehari ialah bagi Rawatan II. Keputusan kajian keseimbangan nitrogen menunjukkan bahawa retensi nitrogen untuk kedua-dua Rawatan III dan IV (masing-masing 9.68 dan 10.24 g sehari) adalah lebih rendah daripada Rawatan II (13.4 g sehari). Hasil eksperimen ini menunjukkan bahawa walaupun efisiensi penggunaan nitrogen oleh lembu tenusu jantan meningkat dengan taburan nitrogen ke tahap 250 kg sehektar setahun, penambahan kadar pembajaan seterusnya tidak menambahkan efisiensi ini. Kajian ini juga menunjukkan bahawa min konsentrasi N-amonia dalam cairan rumen bagi haiwan-haiwan ini berubah dari 63.1 mg se liter bagi foraj 0 kg N kepada 136.6 mg se liter bagi foraj 700 kg N.

Didalam Eksperimen III, pengambilan dan nilai cerna bahan kering bagi lembu-lembu yang diberi makan daun petai belalang pada tahap 10 (Rawatan III) dan 30 (Rawatan IV) g bagi setiap 100 g bahan kering adalah lebih tinggi daripada haiwan tanpa petai belalang (Rawatan I - hanya rumput berbaja dan Rawatan II - rumput berbaja campur urea molasses). Juga didapati bahawa kedua-dua ransum tambahan petai belalang menghasilkan pengambilan tenaga terhadam dan retensi nitrogen yang lebih tinggi daripada ransum tanpa petai belalang. Konsentrasi N-ammonia dalam cairan rumen bagi haiwan-haiwan yang diberi tambahan petai belalang adalah lebih tinggi daripada haiwan yang diberi rumput sahaja tetapi didapati lebih rendah daripada haiwan yang diberi rumput campur urea molasses.

CHAPTER 1

INTRODUCTION

Ruminant production from forage, either beef or milk is achieved when the amount of forage eaten is in excess of that required for maintenance. Its levels are proportional to the daily intake of digestible dry matter and hence depend on the quantity of forage eaten and its digestibility. It has been observed that the nutritional requirements for milk production are greater than for animal growth particularly in terms of digestible energy. For cattle, the nutritional requirements for 1 kg live weight gain equates to that for about 10 kg milk (A.R.C., 1965).

Tropical grasses grow and mature under a high temperature regime. High temperatures stimulate growth and ageing of grasses with a consequent fall in digestibility and protein content. Tropical grasses also have a greater proportion of their dry matter as cell walls, and generally have less soluble carbohydrate than do temperate grasses. In addition, cell wall constituents are less digestible in tropical than temperate grasses. When cut and fed to animals in pens, tropical grasses are on average 13 percent units less digestible than temperate species (Minson and

McLeod, 1970) and intake is 25 percent lower (Minson, 1987). The low intake of tropical grasses is caused by their high cell wall and low crude protein percentage (Minson, 1987).

The intake of forage is usually controlled by the extent and rate of digestion within the rumen (Balch and Campling, 1962). However, when a forage contains insufficient protein, voluntary intake is reduced below that limited by rumen distension (Minson, 1967). The rate of digestion is dependent on the availability of an optimum number of micro-organisms in the rumen. When limits to microbial activity are imposed by low availability of nutrients, especially energy and nitrogen, forage is retained in the rumen for longer period of time and intake is depressed. Since most micro-organisms use ammonia for protein synthesis the availability of ammonia in the rumen will limit microbial growth.

Many tropical grasses are low in crude protein content, and very often the rate of digestion in the rumen is limited by inadequate supply of nitrogen for microbial cell synthesis. Approximately one quarter of all crude protein values reported for tropical grasses in the literature are less than 6 percent (Minson, 1976), a value below which intake is seriously restricted by a protein deficiency (Minson and Milford, 1967).

The crude protein content of forage diets can be increased by use of nitrogen fertilizers, grazing of grass - legume pasture mixture or feeding of nitrogen-rich supplements direct to the animal, such as inclusion of a legume or urea in the diet.

Inclusion of a legume in the diet has distinct advantage in that it provides by-pass protein. Many workers have emphasized that even when nutrients are non-limiting in the rumen, the rumen system may not supply sufficient microbial protein to meet the needs for maximum livestock production. High production has been shown to depend on an additional exogenous amino acid supply to the duodenum through the feeding of by-pass protein.

Experiments were therefore conducted to achieve the following main objectives:

i) to evaluate the effects of nitrogen fertilizer rates on the response of dry matter and protein, concentration of chemical constituents and rumen degradability of the *Setaria sphacelata* var. splendida forage.

ii) to determine the effects of nitrogen concentration of *Setaria sphacelata* var. splendida on forage intake and digestibility, nitrogen utilization and ammonia production in the rumen of dairy bulls.

iii) to determine the effects of *Leucaena leucocephala* and urea supplementation of *Setaria sphacelata* var. splendida on the utilization of energy and nitrogen by dairy bulls.

CHAPTER 2

REVIEW OF LITERATURE

The Nutritive Value of Nitrogen Fertilized Forage

It is generally recognized that livestock performance is controlled primarily by the intake of net energy. Likewise, the value of forage as animal feed is also characterised mainly by its content of net energy. Blaxter (1956) defined nutritive value as a measure of forage ability to promote energy retention in the body as meat and fat, to promote secretion of energy in milk, or to prevent loss of energy from the body (maintenance). This is essentially a measure of net energy intake of forage.

Therefore, in animal production studies the primary aim is to investigate the effect of various forage attributes and different management factors on the intake of net energy and/or animal response. One of the most importance of these factors is nitrogen concentration in the forage. Its level may be increased by nitrogen fertilization or legume inclusion or its dietary level may be upgraded by supplementation. Aspects relating to these subjects will be reviewed in this section.

Dry matter response to nitrogen fertilization

Forage growth is closely related to availability of nitrogen in soils, and high levels of animal production may be achieved from well managed nitrogen fertilized pastures. Tropical grasses are known to have a high potential for dry matter production (Whiteman, 1969; Ludlow and Wilson, 1970). The reported yield potential of 35 - 85 ton/ha per year is very much higher than the yield of 20 - 27 ton/ha per year for the temperate grasses (Cooper, 1970; Strickland, 1974).

Under conditions of adequate rainfall or irrigation the high yield potential can be achieved with the application of high levels of fertilizer, particularly of nitrogen and phosphorous (Vicente-Chandler et al., 1959; Vicente-Chandler et al., 1964; Vicente-Chandler et al., 1974). These workers have reported almost linear dry matter yield responses up to about 400 kg N/ha per year for Napier (Pennisetum purpureum), Guinea (Panicum maximum) and Para (Brachiaria mutica) grass cut every 60 days in Puerto Rico. Similar responses have been reported for Pangola (Digitaria decumbens cv. Pangola) (Adeniyi and Wilson, 1960; Minson, 1967; Whitney and Green, 1969; Hendy, 1972; Ng, 1972; Strickland, 1973), Digitaria setivalva (Chesney, 1972), Brachiaria decumbens (Ng, 1972), Brachiaria mutica (Chadhokar, 1978) and Setaria sphacelata grass (Henzell and Oxenham, 1964; Hacker, 1972; Olsen, 1972; Taylor et al., 1976). Similar responses have been reported by Oyenuga and Hill (1966), Grof and Harding (1970) and Crowder (1974). The general performance of Setaria sphacelata complex has been reviewed by Hacker and Jones (1969). In a recent study by Wong (1980) it was found that the dry matter yield of about 20 tons/ha per year was obtained for Setaria sphacelata var.

splendida defoliated at 5 - 6 weekly intervals and fertilized at 400 kg N/ha per year.

These workers have shown that differences in response to applied nitrogen in terms of dry matter production are due to factors such as species, stages of growth, amount and time of nitrogen applied, soil moisture and climatic conditions.

The high growth potential of tropical grasses is accompanied by efficient nitrogen utilization (Brown, 1978) which enables tropical grasses to grow at a higher rate than temperate grasses even at low tissue percentage nitrogen (Wilson, 1975). The efficiency of nitrogen fertilization of grasses, estimated in terms of kilograms of dry matter produced per kilogram of nitrogen applied, depends to a great extent on the amount of nitrogen used and frequency of cutting, that is stage of growth at the time of harvest. In most cases the efficiency of nitrogen utilization is higher at lower nitrogen rate and at lower cutting frequency.

With Brachiaria ruziziensis, Chloris gayana, Panicum maximum and Setaria sphacelata, Olsen (1972) found that the grasses exhibited a strong response to nitrogen up to 448 kg/ha with a slight additional response up to 896 kg/ha. In this study Olsen (1972) showed that above 896 kg/ha of nitrogen there was an actual decline in dry matter production. He also noted that dry matter production of the grasses increased almost three-fold with high rates of nitrogen. Ng (1972) on the other hand obtained the highest dry matter response at a much lower nitrogen rate. He