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SEASONAL DRY MATTER PRODUCTION AND NITROGEN FIXATION OF LEUCAENA (LEUCAENA LEUCOCEPHALA) AND STYLO (STYLOSANTHES GUIANENSIS) IN PURE SWARDS AND IN ASSOCIATION WITH SIGNAL GRASS (BRACHIARIA DECUMBENS)

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By

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SEASONAL DRY MATTER PRODUCTION AND NITROGEN FIXATION OF LEUCAENA (LEUCAENA LEUCOCEPHALA) AND STYLO (STYLOSANTHES GUIANENSIS) IN PURE SWARDS AND IN ASSOCIATION WITH SIGNAL GRASS (BRACHIARIA DECUMBENS)

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January, 1989

Supervisor : Assoc. Professor Dr. Wan Mohamad Wan Othman

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An experiment was conducted to study the effects of rates of fertiliser nitrogen (N) and grass-legume associations on seasonal and annual dry matter production and forage quality factors of signal grass (Brachiaria decumbens). This study was also designed to estimate the amounts of N_2 fixed over the first two years of establishment by pure stands of leucaena (Leucaena leucocephala cv. ML 1) and stylo (Stylosanthes guianensis cv. Schofield) or their mixtures with signal grass.

Leucaena and stylo were either grown in pure swards or mixed in various combinations with signal grass unfertilised with N. Dry matter production from legume-based pasture was compared with signal grass fertilised with urea at 0, 200, 400, 600 or 800 kg N $ha^{-1}yr^{-1}$.

Signal grass responded markedly to N-fertiliser application, with the highest yield of 18,039 kg dry matter $ha^{-1}yr^{-1}$ (at 800 kg N $ha^{-1}yr^{-1}$) compared with 7,385 kg dry matter $ha^{-1}yr^{-1}$ for the control (0 kg N $ha^{-1}yr^{-1}$). The inclusion of leucaena in signal grass pastures resulted in a substantial increase in total dry matter production and total N yields compared with the control. The total dry matter yields of the grass+leucaena mixtures ranged from 12,223 to 12,690 kg $ha^{-1}yr^{-1}$, equivalent to the yield of signal grass fertilised with 200 kg N $ha^{-1}yr^{-1}$. The inclusion of stylo or the addition of 100 kg N ha^{-1} starter-N to the grass+leucaena mixtures had no significant effects on the growth of leucaena or the total dry matter yield of the grass-legume mixtures. In grass-legume mixtures, the total dry matter and N yields of legumes were markedly reduced compared with those of leucaena (or stylo) in pure stands. Unlike leucaena, the productivity of stylo in pure stands or stylo component in mixtures declined with time.

The estimated amounts of N_2 fixed by leucaena were 300, 240, 155 and 88 kg N $ha^{-1}yr^{-1}$ in pure stands, in mixtures with signal grass, in signal grass+stylo combination and in signal grass+100 kg ha^{-1} starter-N, respectively. Stylo in pure swards fixed 23 kg N $ha^{-1}yr^{-1}$, but in association with signal grass or with signal grass+leucaena, N_2 fixation by stylo increased to 37 and 45 kg N $ha^{-1}yr^{-1}$, respectively. The higher amount of N_2 apparently fixed by stylo in the mixtures was probably due to the poor stylo survival in the pure swards.

In general, the N concentrations of leucaena and stylo were 3.8 and 2.8 g 100 g^{-1}, respectively. In N-fertilised grass, the N concentration and crude protein content increased with increasing rates of fertiliser application. The maximum N concentration was 2.2 g 100 g^{-1} at 800 kg N $ha^{-1}yr^{-1}$. In legume-based pastures, the N concentration and crude protein content of signal grass component were unaffected by the legume association. The various treatments had little effect on the in-vitro dry matter digestibility, mineral concentrations, forage and soil chemical properties.

The applications and implications of this study are discussed with reference to forage management and production in the humid tropics.

Abstrak tesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia sebagai memenuhi sebahagian daripada keperluan untuk Ijazah Master Sains Pertanian

PENGELUARAN BAHAN KERING SEMUSIMAN DAN PENGIKATAN NITROGEN OLEH PETAI BELALANG (LEUCAENA LEUCOCEPHALA) DAN STILO (STYLOSANTHES GUIANENSIS) DITANAM BERASINGAN DAN DALAM CAMPURAN RUMPUT SIGNAL (BRACHIARIA DECUMBENS)

Oleh

AMINAH BT. HJ. ABDULLAH

Januari, 1989

Penyelia : Profesor Madya Dr. Wan Mohamad Wan Othman

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Satu percubaan telah dilaksanakan untuk mengkaji kesan beberapa aras pembajaan nitrogen (N) dan campuran rumput-kekacang terhadap pengeluaran bahan kering tahunan dan pada setiap pemotongan serta faktor kualiti foraj rumput signal (Brachiaria decumbens). Kajian ini juga bertujuan untuk menganggarkan jumlah pengikatan N_2 oleh petai belalang (Leucaena leucocephala kultivar ML 1) dan stilo (Stylosanthes guianensis kultivar Schofield) yang ditanam secara tunggal dan campuran dengan rumput signal dalam masa dua tahun percubaan.

Petai belalang dan stilo ditanam sama ada secara tunggal atau bercampur dengan rumput signal yang terdiri daripada beberapa kombinasi tanpa pembajaan N. Pengeluaran bahan kering pastura yang berasaskan kekacang dibandingkan dengan rumput signal yang diberi pembajaan N (dalam bentuk urea) pada aras 0, 200, 400, 600 dan 800 kg N ha^{-1} setahun.

Rumput signal bertindakbalas secara berkesan terhadap pemberian pembajaan N dengan hasil yang tertinggi sebanyak 18,039 kg bahan kering ha^{-1} setahun (pada aras 800 kg N ha^{-1} setahun) dibandingkan dengan 7,385 kg bahan kering ha^{-1} setahun bagi petak kawalan (0 kg ha^{-1} setahun). Campuran petai belalang dengan rumput menghasilkan pertambahan dalam pengeluaran jumlah bahan kering dan N berbanding dengan petak kawalan. Jumlah hasil bahan kering bagi campuran rumput+petai belalang berada di antara 12,223 dan 12,690 kg ha^{-1} setahun, setara dengan hasil rumput signal yang diberi pembajaan N sebanyak 200 kg N ha^{-1} setahun. Campuran stilo atau pemberian 100 kg N ha^{-1} sebagai N pemula kepada campuran rumput+petai belalang tidak memberi kesan yang ketara terhadap pertumbuhan petai belalang atau jumlah hasil bahan kering campuran rumput+kekacang. Dalam campuran rumput+kekacang, jumlah bahan kering dan jumlah N telah berkurangan dengan berkesan berbanding dengan petai belalang (atau stilo) yang ditanam secara tunggal. Pengeluaran stilo dalam petak tunggal atau pengeluaran komponen stilo dalam campuran dengan rumput berkurangan mengikut masa, tidak seperti petai belalang.

Jumlah pengikatan N_2 oleh petai belalang adalah dianggarkan sebanyak 300, 240, 155 dan 88 kg N ha^{-1} setahun masing-masingnya dalam petak tunggal, campuran dengan rumput signal, dengan rumput signal+stilo dan dengan rumput signal+100 kg N ha^{-1} sebagai N pemula. Stilo dalam petak tunggal mengikat 23 kg N ha^{-1} setahun, tetapi dalam campuran bersama rumput atau dengan rumput+petai belalang, pengikatan N_2 masing-masingnya bertambah kepada 37 dan 45 kg N ha^{-1} setahun. Pengikatan N_2 yang nampaknya lebih tinggi oleh stilo di dalam campuran rumput dan rumput+petai belalang, mungkin disebabkan oleh pertumbuhan stilo yang kurang baik dalam petak tunggal.

Pada amnya, kepekatan N dalam petai belalang dan stilo masing-masingnya sebanyak 3.8 dan 2.8 g 100 g^{-1}. Pada rumput yang diberi pembajaan N, kepekatan N dan kandungan protein kasar bertambah dengan meningkatnya kadar pembajaan. Kepekatan N yang tinggi diperolehi sebanyak 2.2 g 100 g^{-1} pada kadar pembajaan 800 kg N ha^{-1} setahun. Bagi pastura yang berasaskan kekacang, kepekatan N dan kandungan protein kasar rumput signal tidak dipengaruhi oleh campuran kekacang yang ditanam bersama-sama rumput tersebut.

Kesemua perlakuan yang dijalankan tidak memberi kesan terhadap penghadaman bahan kering secara in-vitro, kepekatan mineral dalam foraj dan sifat kimia tanah.

Penggunaan dan implikasi kajian ini dibincangkan dengan memberi perhatian terhadap pengurusan dan pengeluaran foraj di kawasan tropika lembap.

CHAPTER 1

INTRODUCTION

Commercial livestock production in Malaysia has been mainly dependent on nitrogen(N)-fertilised grasses, a system that allows maximum intensification of pasture production. The application of high rates of N fertiliser is necessary to maintain high productivity of fodder grasses in this country (Keeping, 1951; Ure and Mohamad, 1957; Balachandran, 1969; Tan and Pillai, 1975; Tham, 1980). However, manufacturing processes of fertilisers are closely related to the petro-chemical industries, and for N fertiliser alone the energy required accounted for about 94% of the energy used in manufacturing all the fertilisers consumed in developing countries (Halliday, 1982).

About 90% of the ruminant animals in this country are reared by smallholders. Therefore, to encourage and to develop better small-scale farming together with the present shortage of energy supply, it is worthwhile considering legume-based pastures which need relatively low fertiliser inputs.

Systematic introduction and evaluation of pasture grasses and legumes in Malaysia commenced in 1972 (Wong et al., 1982). One of the pasture grasses with agronomic potential is signal grass (Brachiaria decumbens) (Graham, 1951; Anon, 1975; Loch, 1977). Being a vigorous and aggressive grass, it is found to be too competitive for most trailing legumes but it can be utilised in combination with rows of leucaena (Leucaena leucocephala) (De Gues, 1977) or stylo (Stylosanthes guianensis) (Ng, 1976).

Legumes in symbiotic association with Rhizobium have the ability to fix N_2 from the atmosphere. Legumes have been shown to increase soil N content, and the organic matter status of the soil but reduce soil compaction and soil moisture loss (Anon., 1984).

Numerous studies have been carried out highlighting dry matter and animal production of N-fertilised grass pastures, but there is still a lack of information in literature on the productivity of legume-based pastures especially on signal grass+leucaena, signal grass+stylo or signal grass+stylo+leucaena mixtures. In Malaysia, research data on a comparative study on dry matter production of N-fertilised signal grass and legume-based signal grass are also limited. This study aims to investigate the effects of fertiliser N and legumes (stylo and leucaena) on dry matter production and botanical composition of the pastures, and consequently their effects on soil fertility. Secondly, this study attempts to estimate and compare the amounts of N_2 fixed by stylo and leucaena in pure swards and in signal grass mixtures during the first two years of establishment.

CHAPTER 2

REVIEW OF LITERATURE

Sources of Nitrogen (N) for Grassland Production

Various sources of N for growth of pastures are available (Whiteman *et al*., 1974): N from soil, N_2 fixed by microorganisms associated with some tropical grasses, N from industrial synthesis (fertiliser N) and N_2 from fixation by legumes (symbiotic N_2). Fertiliser N and symbiotic-N_2 are the primary sources of N in pasture production.

Nitrogen Requirements and its Absorption by Plants

Nitrogen is essential for plant growth as it is a constituent of all proteins and nucleic acids and hence of all protoplasm. Nitrogen is also a constituent of chlorophyll and it is, therefore, important for photosynthesis, growth and reproduction. Nitrogen concentrations in plants normally range from 0.2 to 4.2% depending upon the species (1.9 to 4.2% as in the legumes), plant part and physiological age (Chapman and Pratt, 1961). Nitrogen is highly demanded by pasture grasses due to the higher photosynthetic rates of grasses than the dicotyledonous field crops (Kalpage, 1977).

Nitrogen deficiency exerts a marked effect on plant growth and yield. Plants remain stunted, all the leaves assume a uniform pale yellow colour and senescence of leaves occurs. An excessive application of N, however, induces a luxuriant development of the subaerial vegetative organ but the root systems remain small. Tissues from these plants are spongy, weak and dark green (Marschner, 1986).

In soil, N occurs mainly in two forms, the readily available inorganic N (nitrate, ammonium or amides as in fertiliser urea) or the slowly available organic compounds. Nitrogen uptake by plants is mainly in the form of NH_4^+ and NO_3^- ions (Gilbert, 1984). Nitrogen reserve held in organic forms are firstly mineralised, the ammonia released being converted by the soil bacteria into nitrates. Since plants continuously withdraw mineral N from soil, more organic matter is degraded to release organic N and restore the N balance (Ismunadji and Makarim, 1987).

Nitrogen Fertiliser and its Availability

Selection of the most appropriate source for N fertiliser depends on the unit cost of N, the need and effectiveness of the fertiliser (Gilbert, 1984). The availability of soil N should also be considered in deciding the rate of fertiliser N to be applied since N use efficiency is low at high soil N levels (Ismunadji and Makarim, 1987). Soil water and temperature also influence the N use efficiency by affecting the rates of mineralisation and immobilisation of soil N (Jansson and Persson, 1982).

Among the nitrogenous fertilisers commonly used for pasture production are ammonium sulphate (21% N), urea (46% N), ammonium nitrate (26% N) and calcium ammonium nitrate (26% N). Ammonium nitrate and calcium ammonium nitrate, which supply N both NH_4^+-N and NO_3^--N can, therefore, be considered as preferred nitrogenous fertilisers for pastures (Kalpage, 1977). When these fertilisers are applied to moist soils, N can be directly absorbed by the plants (Gilbert, 1984). However, the unit cost of N in both of these fertilisers is more than in urea (Kalpage, 1977), the cheapest source of N (Gilbert, 1984) and hence urea is used extensively.

Urea fertiliser, however, cannot be absorbed directly and must be transformed into the NH_4^+ and NO_3^- forms prior to absorption by plants. Urea, in soil, is very quickly hydrolysed to ammonium carbamate and finally to ammonia and carbon dioxide in the presence of urease, an enzyme