UNIVERSITI PUTRA MALAYSIA

EFFECTS OF IRRADIANCE AND CUTTING INTERVAL ON GROWTH, YIELD, PERSISTENCE AND NUTRITIVE VALUE OF *ASYSTASIA INTRUSA*

SUPARJO NOORDIN MOKHTAR

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By

SUPARJO NOORDIN MOKHTAR

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

JULY 2008

DEDICATION

Years have passed with memories like yesterday
It seems like you're still around the same in every way
Though the tears have barely dried from what we tried to say
With daily thoughts of you in our hearts and in our prayer.

We remember the charm the light the spirit you left behind
The love of life the love that binds
The love that only you Noor Hailan Sulaiman can find
And teach us to love and to love divine.

Atiqah and Hanum need you, and Arief and Azrin miss you
Haikal asks for you and Suparjo has to live without you
They say life for us must go on when life left you
But how can we begin to find another you?

The loss in you and the loss we feel
But will time heal what our hearts reveal?
The Lord's way of life is meant to be
Is what life we are meant to see.

None had been a better mother and wife
If only you had some more years of life
We cherish the memory we hold dear
Darling mother and wife you had no peer.

Wassallam.

Source: A modification of poem by James, Melissa, Julian and Jonathan in the Sun 30th August 1996, page 43.

Suparjo Noordin Mokhtar
July 2008

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Doctor of Philosophy

EFFECTS OF IRRADIANCE AND CUTTING INTERVAL ON GROWTH, YIELD, PERSISTENCE AND NUTRITIVE VALUE OF *ASYSTASIA INTRUSA*

By

SUPARJO NOORDIN MOKHTAR

July 2008

Chairman: **Associate Professor Mohd Ridzwan Abd Halim, PhD.**

Faculty: **Agriculture**

Asystasia intrusa, a species introduced 90 years ago, is now a naturalized weed in Malaysia that is prevalent under oil palm plantations. However, this species is known to be very palatable to cattle and goats. Despite being recognized as a shade plant, its response to shade has not been studied. Similarly, the appropriate cutting interval for optimum yield and quality has not been determined. A study was, therefore, conducted to determine the performance of animals consuming *A. intrusa* and the effects of shading and cutting interval on its yield, chemical composition, growth and persistence.

Experiments were conducted encompassing the; i) intake and nutritive value of *A. intrusa* in herbivores when harvested from the field; ii) effects of cutting interval and shade levels on yield, growth, persistence of survival, chemical composition, in vitro dry matter digestibility (IVDMD), essential amino acid (EAA) and mineral

concentrations of *A. intrusa* grown in a glasshouse; and iii) optimum light requirements for photosynthesis.

Asystasia intrusa is very palatable and nutritious for ruminant and non-ruminant herbivores. Adult rams consumed *A. intrusa* dry matter (DM) at a rate of 33 g kg^{-1} body weight. Both acid detergent fiber (ADF) and neutral detergent fiber (NDF) were digested at a rate of 590 g kg^{-1} DM. The digestible energy (DE) and dry matter digestibility (DMD) were 2.1 mcal kg^{-1} DM and 620 g kg^{-1} DM, respectively. In rabbits, the DE and DMD value in this experiment was 2.2 mcal kg^{-1} DM and 509 g kg^{-1} DM, respectively. The mean IVDMD was 612 g kg^{-1} DM for leaf and 451 g kg^{-1} DM for stem which was within the normal digestibility of most forages. The digestibility of CP was quite low with 496 g kg^{-1} CP in rabbits and 500 g kg^{-1} CP for rams. As a result, *A. intrusa* had DCP of 68 g kg^{-1} DM in rams and 101 g kg^{-1} DM in rabbits.

The CP concentration in leaf, stem and aerial part was 326, 167, and 253 g kg^{-1} DM, respectively. Both cutting interval and shade had an effect on the crude protein (CP) concentration. Crude protein in leaf decreased from 354 g kg^{-1} DM at 4 week cutting interval to 303 g kg^{-1} DM at 12 weeks. In stem, CP concentration of young *A. intrusa* was 213 g kg^{-1} DM which declined to 144 g kg^{-1} DM at longer cutting interval. They showed no difference between 8 and 12 week-cutting interval. On the other hand, with increased shading, the leaf CP concentration increased from 278 g kg^{-1} DM in the open to 361 g kg^{-1} DM at 93% shade. Shade has no effect on the CP concentration of stem.

An essential amino acid profile of leaves showed that cystine concentration decreased with higher shade levels, while histidine increased with longer cutting interval. The most limiting EAA were histidine, lysine and methionine in leaf, and histidine and methionine in stem. Lysine concentration of stem was higher than leaf, especially when cut early. Essential amino acid constituted 35.2% of the leaf CP, and 37.7% of stem CP.

Mineral concentrations increased with more shade and longer cutting interval in leaf and stem, except for Mg in leaf. Similarly, the P concentration in leaf increased with age. The ratio of Ca:P was 4.3 in leaf and 5.9 in stem, thus formulation of ration for calcium would be made easier.

The concentration of fiber in *A. intrusa* was low relative to other tropical forages. The concentration of ADF in leaf, stem and aerial parts of *A. int*rusa were 158, 393 and 258 g kg^{-1} DM, respectively. Neutral detergent fiber in leaf, stem and aerial parts were 463, 536 and 494 g kg^{-1} DM, respectively. The ADF, as well as NDF, was highest with long cutting interval in both leaf and stem. They showed no difference in concentrations between 8 and 12 week cutting interval. Shading had contrasting effects on ADF and NDF and on leaf and stem. In the leaf, the ADF decreased while the NDF increased with increasing shade. In contrast, stem ADF increased as shade increased.

The photosynthetic rate of *A. intrusa* increased when incident light was increased from 59 μmol photons m^{-1} s^{-1} to a peak at 600 μmol photons m^{-1} s^{-1} after which it declined. This shows that it is a shade plant with sun tolerant property. The light

compensation point for *A. intrusa* occurred at 81.2 μMol photons m^{-2} s^{-1}. The water use efficiency of *A. intrusa* was 1.46. The efficiency of *A. intrusa* to convert solar energy to chemical energy was 0.018. Shade and cutting intervals affected the morphology and growth of *A. intrusa*. Increasing shade reduced the number of branches and nodes. Plant was shorter (15.5 cm) in the open than in heavy shade (27.0 cm). They flower at all height, with shorter plants tending to have more flowers. In contrast to flower, seed production of *A. intrusa* was higher in taller plants. Canopy size and leafiness was influenced more by cutting interval than by shade. The cumulative annual yield of leaf was only affected by shade, while in stem, both cutting interval and shade affected the annual yield.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah.

KESAN CAHAYA DAN KERAPAN POTONGAN KEATAS TUMBESARAN, PENGELUARAN, KETAHANAN DAN NILAI MAKANAN *ASYSTASIA INTRUSA*

Oleh

SUPARJO NOORDIN MOKHTAR

Julai 2008

Pengerusi : Profesor Madya Mohd Ridzwan Abd Halim, PhD.

Fakulti : Pertanian

Asystasia intrusa yang diperkenal 90 tahun dahulu dari luar negara kini menjadi rumpai alamiah di dalam kebun kelapa sawit. Rumpai ini sangat disukai lembu, dan kambing. Walaupun dikenali sebagai pokok yang suka naugan, tindak balas naungan keatas tumbuhan tidak diketahui. Juga, umur potongan yang sesuai untuk pengeluaran yang optima dan mutu yang baik belum ditentukan. Satu kajian telah dijalankan untuk mengkaji nilai prestasi ternakan yang memakannya dan respon *A. intrusa* kepada naungan dan umur potongan ke atas pengeluaran bahan kering, kandungan kimia, pertumbuhan dan ketahanan.

Uji kaji merangkumi i) kadar pengambilan oleh ternakan, dan nilai pemakanan *A. intrusa* yang dituai dari lading, ii) kesan umur pemotongan dan naungan terhadap pengeluaran, pertumbuhan, ketahanan dari mati, kandungan kimia, pencernaan in

vitro, dan kandungan asid amino perlu dan galian pada *A. intrusa* yang ditanam di dalam rumah kaca, dan, iii) keperluan cahaya untuk proses fotosintesis.

Ternakan ruminan herbivor dan bukan herbivor menggemari *A. intrusa* kerana zatnya. Biri-biri jantan dewasa memakan bahan kering *A. Intrusa* pada kadar 33 g kg^{-1} berat badan. Kadar cerna kedua-dua ADF dan NDF ialah 590 g kg^{-1} BK. Ia mengandungi tenaga dan BKT masing-masing sebanyak 2.1 mcal kg^{-1} BK dan 620 g kg^{-1} BK. Nilai tenaga dan BKT pada arnab ialah masing-masing 2.2 mcal kg^{-1} BK dan 509 g kg^{-1} BK. Berat kering tercerna daun dan batang masing-masing pada kadar 612 g kg^{-1} BK dan 451 g kg^{-1} BK menggunakan cara invitro meletakkan ia setanding dengan rumput lain. Protin kasar dicerna arnab adalah pada kadar 496 g kg^{-1} PK dan 500 g kg^{-1} PK pada biri-biri. Dengan itu, terdapat PKT sebanyak 68 g kg^{-1} BK dari *A. intrusa* bagi biri-biri jantan dan 101 g kg^{-1} BK bagi arnab.

Daun, batang dan bahagian atas tumbuhan ini masing-masing mengandungi PK pada kadar 326 g kg^{-1} BK, 167 g kg^{-1} BK dan 253 g kg^{-1} BK. Kedua-dua umur potongan dan naungan memberi kesan kepada kandungan protein kasar. Protin kasar dalam daun menurun dari 354 g kg^{-1} BK pada 4 minggu umur potongan ke 303 g kg^{-1} BK pada umur 12 minggu. Batang muda *A. intrusa* mengandungi PK yang tinggi sebanyak 213 g kg^{-1} BK dan menurun hingga 144 g kg^{-1} apabila lebih tua. Tidak terdapat perbezaan kandungan PK antara umur potongan 8 dan 12 minggu. Sebaliknya, kandungan sebanyak 278 g kg^{-1} DM protin kasar pada daun di tempat terang meningkat ke 361 g kg^{-1} DM pada 93% naungan. Naungan tidak memberi kesan kepada batang.

Profil asid amino perlu dalam daun menunjukkan penurunan kandungan cistena dengan peningkatan naungan. Histidina pula bertambah dengan kenaikan umur potongan. Asid amino perlu yang paling terhad ialah histidina, lisina dan metionina pada daun, dan histidina dan metionina pada batang. Batang mengandungi lisina yang lebih tinggi daripada daun apabila dipotong awal. Kandungan asid amino perlu dalam daun dan batang masing-masing ialah 35.2% dan 37.7% daripada kandungan PK.

Kandungan galian dalam daun dan batang pada amnya bertambah dengan peningkatan naungan dan umur potongan, kecuali Mg pada daun. Juga, kandungan P dalam daun menurun dengan penigkatan umur potongan Kadar Ca:P ialah 4.3 pada daun dan 5.9 pada batang memudahkan proses membuat ransum makanan.

Asystasia intrusa mempunyai serabut yang rendah berbanding dengan forage lain dari iklim tropika. Bahagian daun, batang dan atas tumbuhan masing-masing mengandungi ADF sebanyak 158, 393 dan 258 g kg^{-1} BK. Manakala kandungan NDF pada bahagian daun, batang dan atas tumbuhan masing-masing mengandungi 463, 536 dan 494 g kg^{-1} BK. Kandungan ADF dan juga NDF sentiasa meningkat dengan pertambahan umur potongan pada kedua daun berlaku juga pada batang. Peningkatan itu tidak perbezaan di antara potongan 8 dan 12 minggu Kesan naungan keatas serabut pula bergantung kepada samada ia ADF atau NDF dan samada daun atau batang. Kandungan ADF menurun dan NDF meningkat jika ia daun dengan penambahan kegelapan. Sebaliknya, ADF pada batang meningkat dalam gelap.

Kadar fotosintesis *A. intrusa* mulai cahaya sebanyak 59 μmol photons m^{-1} s^{-1} meningkat ke kemuncak pada 600 μmol photons m^{-1} s^{-1} dan kembali turun selepas itu. Ini menunjukkan ia pokok jenis hidup bawah naungan tetapi boleh tahan matahari. Titik pampasan cahaya untuk *A. intrusa* ialah 81.2 μMol photons m^{-2} s^{-1}. Kecekapan kegunaan cahaya *A. intrusa* ialah 1.46. Kecekapan *A. intrusa* menukar tenaga suria ke tenaga kimia ialah 0.018. Naungan dan umur potongan memberi kesan kepada mofologi dan pertumbuhan *A. intrusa*. Bilangan buku-ruas dan cabang menurun dengan naungan. *Asystasia intrusa* tumbuh rendah tanpa naungan (15.5 cm) berbanding naungan gelap (27.0 cm). Tumbuhan akan sentiasa berbunga pada semua ketinggian, terutamanya apabila rendah. Bertentangan dengan bunga, biji banyak kelihatan pada *A. intrusa* yang tinggi. Saiz kanopi ditentukan oleh umur potongan dan bukan oleh naungan. Kerimbunannya ditentukan oleh umur potongan dan bukan oleh naungan. Naungan memberi kesan kepada bahan kering terkumpul dalam setahun pada daun, manakala kedua-dua umur potongan dan naungan memberi kesan pada batang.

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Before that, I felt satisfied about the choice of *A. intrusa* as a theme for the thesis. Historically, I stumbled on the species by coincidence. All the while, I have been watching for a plant in Malaysia which is nutritively comparable with alfalfa. In 1986 when touring MARDI with FELDA trainees, Dr Wong Choi Chee showed an *A. intrusa* weed that could reach 240 g kg^{-1} DM protein. I immediately jumped on it. My experience with 18 dairy farmers in USA studying alfalfa hay quality committed me to *A. intrusa*. A high crude protein value and low ADF content was the quality sought when buying hay lots.

Besides, in late 1970s I observed something was lacking in the way animals were fed. For every two wagons of fodder fed to goats, one wagon of left-over remained. It was painful to see time and effort being wasted on securing feed yet the animals was skinny. That was where I began to develop interest on quality of roughage.

Later on, it developed to the effect of the climate on the quality of roughage, as well as on the animal itself.

I thanked Allah swt who bestowed many good people who aided me whenever needed. Many individuals have to be thanked for their assistance. All of them contributed the best they could. Among them were:

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Abdul Rashid bin Dimin, MARDI : Computer problem.
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Chen Chin Peng, MARDI : Discussion
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Faizah Mohamed, MARDI : Preparation & Analysis of samples and NIR.
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Mohd. Yunus Ismail, MARDI : Sample drying and preparation.
Mohd Zahar bin Abu Samah, MARDI : Computer problem.
Morshidi Mostapa, MARDI : PC problems.
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Saridah Pilus, MARDI : Chemical analysis.
Samiyah Mohamad Nasir : Literature.
Sarimah Kahar, MARDI : Computer problem.
Selamat Basar, MARDI : Former Staff, Livestock Department Office.
Siti Rubinah bt Senin, MARDI : Computer service.
Subahir Samijan, MARDI : LCA-2 infrared gas analyzer for photosynthesis.
Syed Jalaluddin bin Syed Salim, Dr : Former Vice Chancellor, UPM as former Chairman of Examination Committee.
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I certify that a Thesis Examination Committee has met on 18th July 2008 to conduct the final examination of Suparjo Noordin Mokhtar on his thesis entitiled "Effects of Irradiance and Cutting Interval on Growth, Yield, Persistence and Nutritive Value of *Asystasia intrusa*" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

Mohd. Razi Ismail, PhD.
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(Chairman)

Dr Dahlan Ismail, PhD.
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South Dakota University
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BUJANG BIN KIM HUAT, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 28 April 2009

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Mohd Ridzwan Abd Halim, PhD.
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Professor and Dean
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Date: 14 May 2009

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations that have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

_____

SUPARJO NOORDIN MOKHTAR

Date: 30 June 2009

TABLE OF CONTENTS

LIST OF ABBREVIATIONS / NOTATIONS / GLOSSARY OF TERMS

AA	Amino acid
ACIAR	Australian Center for International Agricultural Research
AIA	Acid insoluble ash.
ADF	Acid detergent fiber.
AOAC	American Organization of Analytical Chemistry
Aug	August
BK	*Bahan kering*
BKT	*Bahan kering tercerna*
BW	Body weight
CIAT	Centro Internacional de Agricultura Tropical
CF	Crude fiber
CP	Crude protein.
CV	Coefficient of variation.
DBP	Dewan Bahasa dan Pustaka
DCP	Digestible crude protein
DDM	Digestible dry matter.
DE	Digestible energy
DM	Dry matter.
DMD	Dry matter digestibiltiy
DMI	Dry matter intake
EAA	Essential Amino Acid
Feb	February
g	Gram

GE	Gross energy
IVDMD	In vitro dry matter digestibility
Jan	January
kg	Kilogram
kcal	Kilocalory
LSR	Leaf-to-stem ratio
mcal kg^{-1}	Megacalorie per kilogram
MARDI	Malaysian Agricultural Research and Development Institute.
μmol	micromole
μM	micromole (used in graphs)
NAHQC	National Alfalfa Hay Quality Committee
NDF	Nitrogen detergent fiber.
NIR	Near Infra Red
OM	Organic matter
PAR	Photosynthetic active radiation
PD	Partially dried
PFD	Photon Flux Density
PK	*Protin kasar*
PKT	*Protin kasar tercerna*
PPFD	Photosynthetic photon flux density
RHI	Relative humidity (going inside)
RHO	Relative humidity (going outside)
RRIM	Rubber Research Institute of Malaysia
s	Second
s.d.	Standard deviation