

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

SOME ASPECTS OF COMPETITION BETWEEN
A TROPICAL GRASS AND A TROPICAL LEGUME

A thesis presented in partial fulfilment of
the requirements for the Degree of
Master of Agricultural Science
in Plant Science

at

Massey University
Palmerston North
New Zealand

SUPACHAI UDCHACHON
1985

ABSTRACT

Verano stylo (Stylosanthes hamata c.v Verano) and Guinea grass (Panicum maximum c.v Coloniao) are two tropical pasture species reported to be superior in performance to many other species in the northeast of Thailand. A mixed pasture of these two species, therefore, has a potential to produce a high herbage yield in terms of both quantity and quality. Little is known, however, about the compatibility of these two species. A glasshouse experiment was set-up to establish competitive situations between these two species. The experimental design was based on the de Wit model (Replacement series principle).

Dry matter yield per plant of both species decreased markedly when the grass proportion increased. The reduction in dry matter yield was not proportional to the increase in grass proportion. Branch number in legume and tiller number in grass was the yield component most sensitive to plant competition. The results of relative replacement rate analysis indicated that during early stages of growth verano stylo was very sensitive to competition from grass. Verano stylo appeared to compete with the guinea grass more successfully after it had approximately 20 leaves.

An increasing grass proportion had no affect on the shoot/root ratio of the guinea grass but decreased the shoot/root ratio of legume plants

Plant height of guinea grass was decreased by increasing plant competition while legume height was not affected. In contrast, leaf area distribution of

legume was affected by increasing plant competition while that of guinea grass was not affected.

Increasing plant competition decreased herbage quality in both species as measured by the leaf/non-leaf ratio. In addition, under severe competition legume plants also showed a reduction in leaf nitrogen concentration.

Flowering time of verano stylo was markedly affected by competition from guinea grass. Flowering occurred after 7 weeks in the monoculture. In association with grasses flowering was delayed on average 11 weeks in two treatments while in the mixture containing the highest proportion of grass the legume plants remained vegetative throughout the trial.

The results demonstrated that there was no yield advantage from any of mixtures between these two species over the monoculture under the conditions of this study. One of the possible reasons for this severe suppression of verano stylo from the guinea grass plants could have been associated with a consequent reduction in the legume capacity to fix nitrogen. The legume monoculture appeared to produce a higher yield than the other combinations in terms of protein content. Management strategies to help overcome legume suppression are discussed. Options such as reducing grass population relative to legume, establishing the legume before the grass, earlier defoliation, and/or the strategic application of fertilizers.

ACKNOWLEDGEMENTS.

I wish to express my sincere gratitude to my supervisors Mr. P.N.P. Matthews and Dr. A.C.P. Chu for their advice, encouragement, helpful criticism, understanding and patience in discussion, the interpretation of the results and the preparation of this manuscript. Thanks are also due to Dr. C.J. Korte (presently at the MAF. Gisborne) who assisted with initial planing of this study.

I wish to thank Mr. E. Roberts (presently at the MAF. Palmerston North) for his valuable comments and patiently correcting my english in preparing this manuscript.

I am particularly grateful to Professor B.R Watkin (Head, Department of Agronomy) for his encouragement and generosity to me and my family during the course of this study.

I wish to express my gratitude to

- Dr. I.L. Gordon for his advice in the statistical analysis of this study.

- Mr. A.G. Robertson for his assistance in preparation of Rhizobium solution.

- Mr. D. Sollitt, Mr.T. Lynch and his staff for technical assistance.

- The staff and postgraduate students of the Agronomy Department for their friendship and help offered.

- Mrs. F.S. Wicherts who typed part of this draft.

- The Department of Livestock Development, Ministry of Agriculture and Cooperative, Thailand for allowing me leave for this study.

This project was undertaken while I was the recipient of a Scholarship from the New Zealand Government. Therefore to the personnel in the External Aid Division of the Ministry of Foreign Affairs, New Zealand for their support during my period at Massey University..

I am deeply indebted to Mr. M.P Joyce who has assisted me in many aspects and without him I would not have come to study at Massey University.

Finally, I wish to express my deep gratitude to my parents and my wife for their love and support. In particular, my wife, Supaporn, for her sacrifices, concern, understanding, hard work in taking care of me and my son (Tew), patience and assistance in many aspects for my study. To her, I am very grateful.

TABLE OF CONTENTS

	Page
Abstract	ii
Acknowledgements	iv
Table of Contents	vi
List of Tables	ix
List of Figures	x
List of Plates	xii
List of Appendices	xiii
CHAPTER 1. INTRODUCTION AND OBJECTIVES	1
1.1. Introduction	1
1.2. Objective	3
CHAPTER 2 LITERATURE REVIEW	4
2.1. Plant species studied	4
2.1.1. <u>Stylosanthes hamata</u> cv. Verano	4
2.1.2. <u>Panicum maximum</u> cv. Coloniao	5
2.2. Plant competition	7
2.2.1. Definition	7
2.2.2. Nature of plant competition	8
2.2.2.1. Competition for light	9
2.2.2.2. Competition for nutrient	14
2.2.2.3. Competition for water	16
2.2.2.4. Interaction between competition for light and nutrient	17
2.3. Factors affecting competitive ability	18
2.3.1. Plant characters	18
2.3.1.1. Seedling growth rate	18
2.3.1.2. Shoot characters	20
2.3.1.3. Root characters	21
2.3.2. Environmental factors.	23
2.3.2.1. Soil	23
2.3.2.2. Management	26
2.4. The study and measurement of plant competition	29
2.4.1. The additive type of experiment	30
2.4.2. The replacement type of experiment	31

CHAPTER 3.	EXPERIMENTAL MATERIALS AND METHODS.	35
3.1.	The site	35
3.2.	The boxes	35
3.3.	Grass and legume mixtures	35
3.4.	Experimental lay-out	36
3.5.	Sward establishment	36
3.6.	Management	37
	3.6.1. Environmental conditions	37
	3.6.2. Watering	38
	3.6.3. Fertilizing	38
	3.6.4. Rhizobium inoculation	39
3.7.	Measurement	39
	3.7.1. Non-destructive sampling	39
	3.7.2. Destructive sampling	40
3.8.	Statistical analysis	41
	3.8.1. Analysis of variance	41
	3.8.2. Regression analysis	42
	3.8.3. Competitive indices	43
CHAPTER 4	EXPERIMENTAL RESULTS	45
4.1.	Herbage dry matter yield per box	45
4.2.	Plant growth and development	45
	4.2.1. Legume	45
	4.2.1.1. Total dry matter yield per plant	45
	4.2.1.2. Relative growth rate	46
	4.2.1.3. Shoot/root ratio	46
	4.2.1.4. Leaf/non-leaf ratio	46
	4.2.1.5. Days to flowering	47
	4.2.1.6. Leaf numbers and the rate of leaf appearance	47
	4.2.1.7. Branch numbers	48
	4.2.1.8. Nodule numbers	48

4.2.2. Grass	49
4.2.2.1. Total dry matter yield per plant	49
4.2.2.2. Relative growth rate	49
4.2.2.3. Shoot/root ratio	50
4.2.2.4. Leaf/non-leaf ratio	50
4.2.2.5. Leaf numbers and the rate of leaf appearance	51
4.2.2.6. Leaf length	51
4.2.2.7. Tillering	52
4.3. Canopy morphorlogy and light interception	52
4.3.1. Plant height	52
4.3.2. Light interception	52
4.3.3. Leaf area distribution	52
4.4. Plant nitrogen	53
4.4.1. Crude protien yield per box	53
4.4.2. Percent nitrogen in plant	53
4.5. Competitive indices	54
4.5.1. Relative yield total (RYT)	54
4.5.2. Relative replacement rate (RRR)	54
CHAPTER 5. DISCUSSION	55
5.1. Affect of plant competition on dry matter yield	55
5.2. Affect of plant competition on plant growth	57
5.3. The affect of plant competition on shoot/root ratio	62
5.4. The affect of plant competition on plant morphology	63
5.5. The affect of plant competition on plant quality	64
5.6. The effect of plant competition on flowering of verano stylo	66
CHAPTER 6. CONCLUSIONS	68
BIBLIOGRAPHY	70
APPENDICES	100

LIST OF TABLE

<u>TABLE.</u>		Page
4.1.	Plant dry matter yield at the final harvest (week 19)	45a
4.2.	Transformed (log10) treatment means of plant dry weight of verano stylo.	45a
4.3.	Relative branching rate of verano stylo in different combinations.	48a
4.4.	Nodule number of verano stylo	48c
4.5.	Treatment mean of plant dry weight (g/plant) of guinea grass.	49b
4.6.	Relative growth rate of guinea grass	49b
4.7.	Mean plant height of verano stylo.	52b
4.8.	Crude protien yield (g/box) at the final harvest	53a
4.9.	Percent nitrogen in plant components of guinea grass and verano stylo	53a

LIST OF FIGURES

<u>FIGURES.</u>	<u>Page</u>
2.1. Relationship between light interception and leaf area index	10
2.2. Diagram illustrating the basic forms of competition situations according to the replacement series	34
3.1. Lay-out	36a
3.2. Planting arrangement according to the replacement series.	36b
4.1. Dry matter yield of verano stylo (g/plant). (a) Shoot dry matter yield. (b) Root dry matter yield. (c) Total dry matter yield.	45b
4.2. Relative dry weight per plant of verano stylo at the final harvest (week 19)	45c
4.3. Relative growth rate (mg/mg/week) in relation to shoot dry matter yield of verano stylo.	46a
4.4. Shoot/root ratio of verano stylo.	46b
4.5. Leaf/non-leaf ratio in relation to shoot dry matter yield of verano stylo.	46b
4.6. (a) The number of leaves per plant of verano stylo. (b) Relative rate of leaf appearance of verano stylo in mixtures to monoculture (monoculture equals 100).	47a
4.7. The number of branches per plant of verano stylo.	48a
4.8. Shoot dry matter yield (g/plant) in relation to the number of branches of verano stylo in different grass-legume proportion.	48b
4.9. Dry matter yield of guinea grass (g/plant) (a) Shoot dry matter yield. (b) Root dry matter yield. (c) Total dry matter yield.	49a

4.10.	Relative dry weight per plant of guinea grass at the final harvest (week 19).	49c
4.11.	Relative growth rate (mg/mg/week) in relation to shoot dry matter yield of guinea grass.	49c
4.12.	Shoot/root ratio of guinea grass	50a
4.13.	Leaf/non-leaf ratio in relation to shoot dry matter yield of guinea grass.	5 a
4.14.	(a) Rate of leaf appearance of guinea grass (b) Relative rate of leaf appearance of guinea grass (75L:25G mixture equals 100).	51a
4.15.	The number of leaves on a primary plant of guinea grass	51b
4.16.	The length of fully expanded leaves on a primary plant of guinea grass.	51b
4.17.	The number of tillers per plant of guinea grass.	51c
4.18.	Plant height. (a) Verano stylo (b) Guinea grass	52a
4.19.	Light interception at the legume canopy.	52b
4.20.	Leaf area distribution in the canopy. (a) Verano stylo (b) Guinea grass	52c
4.21.	Relative yield total of shoot dry matter yield.	54a
4.22.	Relative yield total of root dry matter yield.	54b
4.23.	Relative yield total of crude protien yield.	54c
4.24.	Relative leaf number of guinea grass to relative leaf number of verano stylo in relation to growth stage of verano stylo.	54c

LIST OF PLATESPLATES.

	Page
3.1. The boxes	35a
4.1. Verano stylo at the final harvest.	45c

LIST OF APPENDICES

<u>APPENDICES.</u>	<u>Page</u>
3.1. Harvesting date	100
3.2. Daily-minimum and maximum temperature during the experimental period.	100
4.1. A comparison of t-values from tabular ($P < 0.05$) and from the estimated values from figure 4.8	101
4.2. The number of leaves when guinea grass started tillering	102
4.3. Leaf area and leaf area index of guinea grass over time.	103
4.4. Plant dry matter yield at the final harvest (week 19).	104
4.5. Method of estimating light interception at the legume canopy.	104
4.6. Relative growth rate of guinea grass and verano stylo in monoculture during week 1-5.	105

CHAPTER 1

INTRODUCTION AND OBJECTIVE

1.1 Introduction

About half of the world's grazing animals are in the tropics, but output of animal products from this land is very much less than the rest of the world (Humphreys, 1980b). One of the reason is due to the grazing animal's heavy reliance on natural grassland resource, with its low productivity (Jones, 1972; Humphreys, 1980a; Shelton, 1983). The productivity of natural grassland is limited both in terms of quantity and quality. These limitations may be partly overcome by oversowing natural grassland with improved legume species, or by replacing the natural grass land species with selected high quality sown grass and legume species. The oversown legume species increases the natural grassland productivity by increasing the amount of forage grown, by its high nutritive value, and improving soil fertility (through its nitrogen fixation). For an intensively managed improved pasture, legume species also play an important role in pasture productivity, maintaining soil fertility, and animal production. This can be seen in many temperate countries, for instance in New Zealand where pasture production is based on a mixed legume-grass sward. However, the question "What is the best proportion between grass and legume to get the highest yield in term of both quality and quantity?" remains unanswered. This is generally due to grasses having the potential to produce a higher yield than legumes but the nutritive value of legumes is considerably higher than that of grasses in terms of dry matter

digestibility and voluntary intake. For instance Playne and Haydock (1972) found that dry matter digestibility of Stylosanthes humilis was 58 percent while that of spear grass Heteropogon contortus at the same plant age (110 days) was 43 percent, and voluntary intake was 67 and 31 (g/day/W^{0.75}), respectively. When legumes and grasses are grown as a mixture their combined productivity is affected by competitive relationships between species in the community. Therefore, the quantity and quality of a mixed pasture is likely to be determined by the proportions of grass and legume.

In the northeast of Thailand, Panicum maximum and Stylosanthes hamata have been reported to be superior in performance to many other pasture species. Topark-ngarm et al (1977a) and Gutteridge (1979) showed that Stylosanthes hamata (cv. Verano) "verano stylo" produced a higher yield than Centrosema pascuorum (Commonwealth Plant Introduction (CPI) 40060), C. pubescens, Macroptilium atropurpureum cv. siratro, S. hamata (CPI 55831), S. guianensis (CPI 40294, cv. Endeavour), S. humilis (cv. Patterson, CPI 61674), Alysicarpus vaginalis. Verano stylo also grew more successfully than many other legume species including the species mentioned above when grown with pasture grass species such as "Sabi" grass (Urochloa mosambicensis) (Topark-ngarm et al 1977; Gutteridge, 1979; Torssel, et al., 1976).

Topark-ngarm et al (1979b) showed that "Guinea" grass (Panicum maximum) produced a consistently higher yield than many other grass species including Cenchrus ciliaris (cv. Biloela), Melinis minutiflora, Chloris gayana, Setaria anceps (cv. Nandi), and Brachiaria decumbens (cv. Signal). The two pasture species (Guinea

grass and Verano stylo) were selected for this study as they appear to have the highest potential productivity in a mixed sward and also little is known about their compatibility.

1.2 Objective

This study has two objectives.

1. To investigate the effect of the different proportion of grass and legume on total dry matter yield.
2. To investigate the effects of plant competition on morphology, quality, growth and development of guinea grass and in particular verano stylo.

This study conducted over the establishment phase only.