

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.

A STUDY OF THE GERMINATION AND ESTABLISHMENT OF
LUCERNE (MEDICAGO SATIVA L.) OVERSOWN ON AN
UNCULTIVATED GRASS SWARD

A thesis presented in partial fulfillment of the
requirements for the DEGREE OF MASTER OF AGRICULTURAL
SCIENCE (M.AGR.SCI) AT MASSEY UNIVERSITY.

Martin Lawrence Kusekwa

1977

ABSTRACT

In this study on the oversowing of lucerne on an uncultivated sward at Massey, three trials were conducted, two in the field and one box trial under glasshouse conditions during the summer of 1975/76 and the autumn and early winter of 1976. The trials compared the effects of two lengths of ground cover, untreated, suppressed for a longer or shorter period with herbicides and burnt on the early establishment of lucerne sown as bare or pelleted seed.

It was found that small amounts of cover at sowing encouraged lucerne germination under high moisture conditions. Subsequent establishment and early survival was best on the burnt and chemically desiccated plots. The cover was most useful where it was short (8 cm) and desiccated by long term paraquat or glyphosate treatments. Dense live cover was harmful to lucerne seedlings and smothered them within 5 weeks after sowing. Where recovery of the resident vegetation and weeds was rapid, as on the burnt and short term herbicide plots, lucerne establishment and survival was poor and surviving plants were small and weak.

Weed infestation was heavy both on burnt and herbicide treated plots, pointing to the need to introduce an early weed control programme with oversowing. Weeds were found to respond in a similar manner to lucerne to grass competition.

In the autumn and early winter trials, slug damage was observed and this problem appeared to be of major importance under wet conditions. The effects of slugs were found to be most damaging during the first 4-5 weeks after sowing. Metaldehyde slug bait pellets were effective in reducing slug damage if applied at least twice during the establishment period of lucerne.

The implications of these findings are reported and discussed with particular reference to the possibilities of oversowing under East African conditions.

ACKNOWLEDGEMENTS

The writer wishes to thank the following for their assistance during the course of this study:-

Dr G. Ivens and Mr E. Roberts of the Agronomy Department, Massey University for their guidance and many helpful suggestions in the supervision of this work.

Professor B.R. Watkin, Head of the Agronomy Department, for his willing help and advice.

Dr I. Gordon and Mr A. Chu for helping me with the analysis of data and allowing me to use their computer programmes.

Mr C.G. Janson for his very useful suggestions and advice.

The entire staff of the Agronomy Department for their willingness to help and advise.

Dr J.F.L. Charlton of Grasslands Division, D.S.I.R., Palmerston North, Dr M. J. Hill and Mr R.E.H. Sims of the Agronomy Department, Massey University for permission to quote their as yet unpublished results.

Mrs G. Kusekwa and various friends for their cheerful encouragement often under trying circumstances.

Mrs J. Humphries, Secretary to the Agronomy Department, Massey University for her care and diligence in typing the thesis.

Mrs M.J. Merriman for proofreading the thesis and last but not least, the New Zealand and Tanzanian Governments for awarding me the Scholarship and in particular to the Tanzanian Government for granting me a study leave.

TABLE OF CONTENTS

	<u>Page</u>
Abstract	(iii)
Acknowledgement	(iv)
Table of Contents	(v)
List of Figures	(xi)
List of Plates	(xii)
List of Tables	(xiii)
1. INTRODUCTION	1
1.1 Grasslands	1
1.1.1 Natural Grasslands	1
1.1.1.1 Mbuga Grasslands	1
1.1.2 Sub-climax Grasslands	1
1.1.3 Artificial Grasslands	2
1.2 Importance of Grasslands	2
1.3 Grassland Development	2
2. LITERATURE REVIEW	7
2.1 Pasture Development	7
2.2 Pasture Development Techniques	7
2.2.1 Conventional Seedbed Preparation	
by Cultivation	8
2.2.1.1 Tillage	8
2.2.1.2 Levelling	9
2.2.1.3 Consolidation	9
2.2.1.4 Additional Effects	9
2.2.2 Reduced Cultivation	10
2.2.3 Zero Cultivation	10
2.3 Pasture Development by Oversowing	12
2.3.1 Grazing	14
2.3.2 Burning	15
2.3.3 Herbicides	16
2.3.3.1 Types of Herbicides Used	17
2.3.4 Factors Causing Losses	18
2.3.4.1 Loss of Seeds	18
2.3.4.2 Loss During Germination	18
2.3.4.3 Loss While Radicle Penetrating Soil	18
2.3.4.4 Loss During Establishment	19

2.3.4.5	Loss of Establishing Seedlings	20
2.3.5	Fertilizer Application	20
2.4	Surface Sowing of Lucerne	21
2.4.1	Lucerne as a Pasture Legume Species	21
2.4.2	Lucerne Establishment Requirements	21
2.4.2.1	Agronomy of Lucerne	21
2.4.2.2	Requirements for Germination and Emergence	22
2.4.2.2a	Soil Moisture	23
2.4.2.2b	Soil Temperature	23
2.4.2.2c	Seed Quality	23
2.4.2.2d	Depth of Sowing	24
2.4.2.3	Requirements for Seedling Survival and Growth	24
2.4.2.3a	Soil Moisture	24
2.4.2.3b	Light	25
2.4.2.3c	Temperature	25
2.4.2.3d	Soil Fertility	27
2.4.2.4	Lucerne Nodulation Requirements	27
2.4.2.4a	The Process of Nodulation	27
2.4.2.4b	Factors Affecting Rhizobial Survival	28
(i)	Level of Inoculum	28
(ii)	pH	29
(iii)	Moisture	29
(iv)	Temperatures	30
(v)	Light	30
(vi)	Seed Pelleting	30
(vii)	Biological Antagonism	31
2.4.3	Establishment Procedures	32
3.	METHOD AND MATERIALS	34
3.1	Preliminary Work	34
3.2	Trial 1	34
3.2.1	Laying Down of Plots	34
3.2.2	Treatments	34
3.2.2.1	Existing Vegetation Treatment (seedbed preparation)	34
3.2.2.1 (a)	Control	35
3.2.2.1 (b)	Short Term Herbicide	35
3.2.2.1 (c)	Longer Lasting Herbicide	35
3.2.2.1 (d)	Burning	35

3.2.2.2	Seed Treatment	39
3.2.3	Sowing	39
3.2.4	Measurements (observations)	40
3.2.4.1	Herbage Sampling	40
3.2.4.2	Soil Moisture Content Determination	40
3.2.4.3	Seedling Counting and Scoring	40
3.2.4.4	Botanical Composition	41
3.2.4.4 (a)	Visual Assessment	42
3.2.4.4 (b)	Herbage Dissection	42
3.2.4.5	Lucerne Growth	42
3.2.4.6	Soil Analysis for Nutrient Status and pH Determination	42
3.3	Trial 2	43
3.3.1	Existing Vegetation Treatment	43
3.3.1.1	Short term herbicide treatment	43
3.3.1.2	Long lasting (term) herbicide treatment	46
3.3.2	Sowing	46
3.3.3	Slug Counts	46
3.3.4	Botanical Composition	46
3.3.5	Soil Moisture Content Determination	46
3.4	Trial 3	48
3.4.1	Treatments	48
3.4.1.1	Vegetation	48
3.4.1.2	Moisture Regime	48
3.4.1.3	Sowing	48
3.4.1.4	Slug Bait Pellets	48
3.4.2	Measurements	49
3.4.2.1	Seedling Counts and Scoring	49
3.4.2.2	Slug Counts	49
3.4.2.3	Moisture Levels	49
3.4.2.4	Growth and Development	49
3.4.2.5	Botanical Composition	49
3.5	Analysis of Results	50
4	RESULTS	51
4.1	Trial 1	51
4.1.1	Germination and Establishment	51
4.1.2	Ground Cover Dry Matter	53
4.1.2.1	Initial dry matter of cover and regrowth	53

4.1.2.2	Relationships between lucerne seedling numbers and dry matter cover during the first 5 weeks after sowing	56
4.1.3	Soil Moisture and Rainfall	59
4.1.3.1	Seedling Count and Soil Moisture Relationships during the first 35 days of lucerne growth	63
4.1.4	Relationships between Germination/Establishment, Ground Cover Dry Matter and Soil Moisture	63
4.1.5	Lucerne Growth at Conclusion of Experiment 96 days (14 weeks) after sowing	66
4.1.5.1	Botanical Composition by dissection and visual assessment	66
4.1.5.2	Individual plant weights (total of shoot and root), nodule numbers and shoot/root ratios	70
4.2	Trial 2	72
4.2.1	Germination and Establishment	72
4.2.2	Ground Cover Dry Matter	74
4.2.2.1	Relationships between seedling numbers and ground cover dry matter	79
4.2.3	Soil Moisture and Rainfall	79
4.2.4	Relationships Between Lucerne Germination/Establishment and Ground Cover Dry Matter and Soil Moisture	83
4.2.5	Slug Activity	83
4.2.6	Survival of Oversown Lucerne	84
4.3	Trial 3	85
4.3.1	Germination and Establishment	85
4.3.1.1	Lucerne Establishment and Slug Activity	88
4.3.2	Soil Moisture	90
4.3.3	Relationship between Final Seedling Numbers and Soil Moisture Levels of the Less Frequent Watering Regime	94
4.3.4	Survival of Oversown Lucerne under Glasshouse Conditions	94

4.3.4.1	Botanical Composition (dissection of cut herbage) at the Conclusion of trial 3, 39 days after sowing	94
4.3.4.2	Lucerne growth by conclusion of trial	100
5	DISCUSSION	103
5.1	Seedbed Preparation Methods - Their Effects on Cover	103
5.1.1	Herbicides	103
5.1.2	Burning	104
5.1.3	Controls	105
5.1.3.1	Short Cover (simulating grazing)	105
5.1.3.2	Long Cover	105
5.2	Treatment Effects	106
5.2.1	Effects of Pelleting (coating)	106
5.2.2	Soil Moisture	107
5.2.3	Effects of Cover on Germination and Early Establishment	108
5.2.3.1	Burnt Cover	108
5.2.3.2	Herbicide Treated Cover	108
(a)	Short Cover	108
(b)	Long Cover	109
5.2.3.3	Controls (live cover)	110
5.2.4	Effects on Subsequent Growth	113
5.2.4.1	Botanical Composition	113
5.2.4.2	Lucerne Growth and Development	114
(a)	Individual lucerne plant dry weights	114
(b)	Shoot/root ratios	115
5.3	Complications Due to Pests	116
6.	GENERAL CONCLUSIONS	118
7.	REFERENCES	120
8.	APPENDICES	
Appendix 1:	Experimental Layout for Trials 1 and 2	
Appendix IA:	Description of Treatments in Trial 1	
Appendix IB:	Description of Treatments in Trial 2	

- Appendix 2: Experimental Layout for Trial 3
Appendix 2A: Description of Treatments
in Trial 3.
- Appendix 3: Glossary of herbicides cited in the text.
- Appendix 4: Effects of Ground Cover Treatments on
lucerne germination and survival during
days of growth.
- Appendix 5: Weekly Rainfall (mm) for the month of
* November to March.
- Appendix 6: Weekly Rainfall (mm) for the months of
April to June.
- Appendix 7: Weed Species found on plots of Trial 2,
16 weeks after herbicide treatment application.
- Appendix 8: Statistical Analyses - Examples
Appendix 8A: Analysis of Variance, Seedling
Count 1 - Trial 1.
Appendix 8B: Analysis of Variance, Seedling
Count 1 - Trial 2.
Appendix 8C: Analysis of Variance, Seedling
Counts 1 and 2 - Trial 3.
Appendix 8D: Correlation Coefficients
Analysis - Trial 2.
- * Appendix 5A: Botanical Composition (Dissection)
Trial 1.

LIST OF FIGURES

	<u>Page</u>
Figure 1: Ground cover dry matter 5 days before sowing and regrowth in Trial 1.	55
Figure 2: Relationships between seedling count 1 and ground cover dry matter - Cuts 1 and 2.	57
Figure 3: Relationships between seedling count 2 and ground cover dry matter - Cuts 2 and 3.	58
Figure 4: Soil moisture levels at various periods during the first trial.	62
Figure 5: Relationships between seedling Count 1 and soil moisture levels taken at various stages during the 15 days of lucerne growth.	64
Figure 6: Relationships between seedling count 2 and soil moisture levels taken between 15 and 35 days after sowing.	65
Figure 7: Botanical composition - Trial 1.	68
Figure 8: Ground cover dry matter at sowing and regrowth - Trial 2	76
Figure 9: Relationships between seedling count 1 and ground cover dry matter - cuts 1 and 2, Trial 2.	77
Figure 10: Relationships between seedling count 2 and ground cover DM - cuts 2 and 3, Trial 2.	78
Figure 11: Soil moisture levels at various periods during Trial 2.	82
Figure 12: Botanical Composition - Trial 2.	84a
Figure 13: Seedling Counts (% of seed sown) and slug counts, Trial 3.	89
Figure 14: Soil moisture levels at each of the more and less frequent watering regimes.	92
Figure 15: Relationship between seedling numbers of count 4 and soil moisture levels of the less frequent watering regime.	93
Figure 16: Botanical composition - Trial 3	96
Figure 17: Relationship between individual lucerne plant dry weights and nodule numbers.	102

LIST OF PLATES

	<u>Page</u>
Plate 1: Grass growth at experimental site before treatment application, Trial 1.	36
Plate 2: General view of experimental site after application of treatments.	36
Plate 3: Long cover + short term herbicide (Para 2) plot 5 days before sowing.	37
Plate 4: Short cover + long lasting (term) herbicide (Para 1) plot 5 days before sowing.	37
Plate 5: Paraquat 2+ burn plot 5 days before sowing.	38
Plate 6: Frame use in the sowing operation.	38
Plate 7: Long cover control plot of Trial 2 at sowing.	44
Plate 8: Short cover control plot of Trial 2 at sowing.	44
Plate 9: Long cover + long term herbicide plot of Trial 2 at sowing.	45
Plate 10: Short cover + short term herbicide plot of Trial 2 at sowing.	45
Plate 11: Paraquat + burn plot of Trial 2 at sowing.	47
Plate 12: General arrangement of boxes in the glasshouse in Trial 3.	47
Plate 13: Short cover control plot at the end of Trial 1.	69
Plate 14: Long cover + paraquat 1 plot at the end of Trial 1.	69
Plate 15: Sowing implement used in Trial 3.	97
Plate 16: Live cover and drying conditions box.	97
Plate 17: Dead cover and moist conditions at the end of Trial 3.	98
Plate 18: Burnt cover and moist conditions at the end of Trial 3.	98
Plate 19: Burnt cover and drying conditions at the end of Trial 3.	99
Plate 20: Stages of growth of lucerne seedling at the end of Trial 3.	99

LIST OF TABLES

	<u>Page</u>
Table 1: Rainfall, humidity and temperature of two selected areas in Tanzania compared to those at Massey.	5
Table 2: Top dry weight of lucerne seedlings, var. Ranger (gm/plot) grown at four air temperatures and three light intensities for 45 days.	27
Table 3: Seed germination test results.	39
Table 4: Lucerne seed germination and development score.	41
Table 5: Nutrient status and pH levels of experimental site.	43
Table 6: Effects of ground cover treatments on lucerne germination and survival 15, 35 and 91 days after sowing.	52
Table 7: Ground cover dry matter (kg/ha) of cuts taken at sowing and subsequent counting and scoring dates.	53
Table 8: Soil moisture levels from samples taken at various stages during Trial 1.	60
Table 9: Daily rainfall (mm) for December 1975 through to 31st March, 1976.	61
Table 10: Effects of cover treatments on final percentage lucerne in herbage.	66
Table 11: Effects of cover and seed treatment on lucerne dry weights and nodule numbers.	70
Table 12: Influence of ground cover during the first 35 days of lucerne germination and establishment on individual plant dry weight (gm) at the end of Trial 1.	71
Table 13: Germination and establishment of lucerne 16, 25 and 35 days after sowing on 16-18/4/1976.	73
Table 14: Ground cover dry matter (kg/ha) assessments at sowing and at various times afterwards in Trial 2.	74
Table 15: Soil moisture content (% in top 5.1 cm layer)	80
Table 16: Daily rainfall (mm) during Trial 2.	81
Table 17: Slug estimates from different cover treatments (Totals of 3 counts over period 12/6/1976) in Trial 2.	83

Table 18: Botanical composition by dissection of herbage cut on the 11/6/1976, 65 days from herbicide application.	84
Table 19: Effects of various cover treatments on lucerne germination and establishment in box trial under glasshouse conditions.	86
Table 19a: Seedling numbers (% of seed sown) in relation to cover and moisture regimes.	87
Table 20: Slug numbers estimations in relation to covers and moisture regimes.	88
Table 21: Moisture content of top 5.1cm soil layer (% of oven dried soil) - Means of 4 replicates.	90
Table 22: Botanical composition by dissection of herbage cut from 250 cm ² quadrat per box, 39 days after sowing.	95
Table 23: Final plant dry weights (shoot + root), nodule numbers and shoot/root ratios.	101