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JUNE 1985 - MAY 1986 (FINAL REPORT)

3 - P - 82 - 0205: Final Technical Report

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* Covers both centre and recipient administered funds.

ABSTRACT

The performance (July 1983 - May 1986) of afforestation trials in Dodoma Tanzania is outlined. The trials indicate that:-

- Good survival in early planted, 12 month old *E. camaldulensis* seedlings raised in 20cm long polythene tubes into which 25 grams of aladrin, and 30 grams NPK have been added to every 20 litres of potting mixture.

- *Eucalyptus papuana* and *E. microtheca* are promising species, this shows an obvious need for continued species trials.

- Ploughing and harrowing is so far the best site preparation technique. Various manuring intensities did not influence surival and height growth in *E. camaldulensis*.

- Spacing trials varying between 2.5 x 2.5m and 4.0 x 4.0m are recommended subject to site and species requirements.

- *Eucalyptus microtheca* and *E. tereticornis* provenances are suited for hills and their slopes and upper pediments whereas a further selection of seed sources from Northern populations of *E. camaldulensis* is urged.

- *Agave sisilana* is recommended for livehedges and a further search of livehedge - site interactions is proposed.

The adoption of such intensive management practices raise the expenditure stakes in the entire outlay. It is expected that subsequent harvests from coppicing stands will be compensatory.

3 - P - 82 - 0205: Final Technical Report.

C O N T E N T S

1.0 INTRODUCTION

During the year ending in May 1986 project work was focused on:

- Recording and analysis of meteorological data
- Maintenance and assessment of experimental plots initiated both in the first and second phase of the project.

2.0 METEOROLOGICAL DATA

The weather conditions obtaining at Dodoma Meteorological station are summarised in Table 1. As the station is highly correlated with other stations in the district (r = 0.92) it is believed that the weather conditions for all experimental sites broadly fall in this framework.

Table 1. Temperature (°C), Relative humidity (%), rainfall (mm), and raindays (days) from July 1983 to May 1986, Dodoma Met. station, Tanzania.

Month		Temperature		Relative Humidity			Rainfall*	Raindays
		Min.	Max.	Min.	Max.			
						I	-	-
Jul	a)	14.5	26.7	26.2	96.4	II	-	-
						III	-	-
						I	-	-
July	b)	14.0	26.3	27.0	97.4	II	-	-
						III	-	-
						I	-	-
	c)	12.8	25.7	14.3	89.3	II	-	-
						III		
						I	-	-
	a)	14.0	27.8	24.9	94.5	II	-	-
						III	-	-
						I	-	-
August	b)	13.4	22.3	24.1	96.9	II	-	-
						III	-	-
						I		
	c)	13.3	26.5	48.4	89.9	II	-	-
						III	-	-
						I	-	-
	a)	15.1	29.6	22.6	96.3	II	-	-
						III		
						I	-	-
September	b)	11.2	29.4	34.9	87.5	II	-	-
						III	-	-

Table 1 Contd.

Month		Temperature Min.	Temperature Max.	Relative Humidity Min.	Relative Humidity Max.		Rainfall	Raindays
						I	-	-
	a)	16.3	30.7	24.8	95.8	II	-	-
						III	-	-
						I		
October	b)	17.1	32.0	25.9	99.7	II	-	-
						III	-	-
						I	-	-
	c)	16.2	29.4	37.9	81.7	II	-	-
						III	-	-
						I	-	-
	a)	14.0	31.9	20.5	98.8	II	13.5	2
						III	5.7	2
						I	4.3	1
November	B)	18.0	33.7	42.5	90.6	II	72.7	3
						III	-	-
						I	36.3	2
	b)	17.4	29.2	40.1	87.3	II	50.0	1
						III	29.3	1
						I	1.1	1
	a)	15.3	29.2	29.3	93.4	II	56.9	4
						III	158.6	6
						I	29.7	3
December	b)	19.1	26.0	48.5	91.4	II	107.3	6
						III	17.5	3
						I	86.3	4
	c)	17.5	28.0	45.7	88.4	II	57.3	3
						III	50.3	3
						I	26.9	4
	a)	17.3	27.3	40.9	99.3	II	104.9	5
						III	52.9	5
						I	1.9	2
January	b)	19.0	31.2	46.6	94.0	II	34.6	1
						III	125.5	5
						I	151.5	1
	c)	18.0	28.8	56.7	88.2	II	140.3	6
						III	-	-

Table 1 Contd.

Month		Temperature Min.	Temperature Max.	Relative Humidity Min.	Relative Humidity Max.		Rainfall	Raindays
						I	78.7	4
	a)	17.6	28.5	52.3	94.2	II	26.9	6
						III	5.3	2
						I	83.7	8
February	b)	17.0	24.5	60.2	87.3	II	94.6	7
						III	50.6	3
						I	91.0	4
	c)	16/6	30.4	43.4	79.0	II	102.0	6
						III	-	-
						I	-	-
	a)	14.4	30.3	48.1	91.7	II	44.7	4
						III	8.9	3
						I	101.0	3
March	b)	18.3	29.9	55.0	97.6	II	-	-
						III	37.8	5
						I	137.0	5
	c)	15.3	36.7	48.0	56.0	II	152.5	5
						III	27.5	2
						I	-	-
	a)	17.1	28.3	25.5	94.7	II	109.3	4
						III	5.8	3
						I	33.0	3
APRIL	b)	17.9	28.5	23.0	81.8	II	36.0	3
						III	-	-
						I	39.3	3
	c)	17.5	30.1	43.4	93.7	II	6.5	1
						III	13.0	2
						I	-	-
						II	-	-
						III	-	-
						I	-	-
May	Not available					II	-	-
						III	-	-
						I	-	-
						II	-	-
						III	-	-
					(a)		700.0	55
				Total	(b)		830.2	56
					(c)		1170.1	49

Notes: *Records are in 10 day intervals.

(a) July 1983 - May 1984 (b) July 1984 - May 1985

(c) July 1985 - May 1986.

Table 1 shows that the 1985/86 rainy season was wetter than the previous two seasons. However, most of the rain 27 per cent was received in March which is close to the end of the seasons. Furthermore, the Table shows there is no month that clearly emerges as the rainiest. This is in contract with earlier analysis based on long term rainfall data (Nshubemuki et al. 1978) that suggest December/January as the rainiest months. However, reference to the large standard deviations found, it is not unexpected to find that rainfall data based on a short period discordant with the aforementioned analysis.

3.0 MAINTENANCE AND ASSESSMENT OF EXPERIMENTAL PLOTS

3.1. Active Phase I and Phase II experiments were tended and assessed. The following pages outline the present status of the experiments.

3.1. Phase I experiments

3.1.1. Nursery and plant production experiments

There is one, semi-active experiment in this Category. The experiment is located at Nkurugane. Survival continued decreasing (Table 2). The experiment can not be analysed as in the final report for phase I. However, earlier findings by Nshubemuki and Maphole (1984) (P.36),

Table 2. Mean survival and Height growth for the 3.3(a) and 4.3 (b) year old *E. camaldulensis* stock size (age) legth of polythene tube and time of planting experiment at Nkurugane Dedema Tanzania.

Time of planting (No. of green Plots)	Age of Planting stock (months)	Length of Polythene tube (cm)	No. of dried Plots* (a)	No. of dried Plots* (b)	Remaining Plots: Survival (%) (a)	Survival (%) (b)	Mean Height (m) (a)	Mean Height (m) (b)
Early Planting (7)	4	10	3	4	1	0	0.13	0.00
		20	2	3	4	20	0.40	0.70
	8	10	3	3	1	1	0.13	0.29
		20	1	3	14	32	0.45	0.53
	12	10	0	3	23	33	0.67	0.75
		20	0	1	37	41	0.81	1.01
Mid Planting (9)	4	10	2	3	11	32	0.38	0.61
		20	0	2	27	48	0.73	1.55
	8	10	1	2	28	50	0.47	0.91
		20	1	3	15	56	0.52	0.90

Table 2 Contd.

Time of Planting (No. of green Plots)	Age of Planting Stock (months)	Length of Polythene tube(cm)	No. of dried Plots*		Remaining Plots			
					Survival (%)		Mean Height (m)	
			(a)	(b)	(a)	(b)	(a)	(b)
Late Planting (7)	4	10	2	3	8	20	0.32	0.70
		20	3	3	13	13	0.16	1.20
	8	10	2	3	8	28	0.30	1.20
		20	2	3	9	48	0.15	0.80
	12	10	2	3	12	20	0.31	0.80
		20	1	2	18	30	0.39	0.70

* Out of a total of four (in four blocks)

for all seasons and different ages of planting stock, seedlings raised in 20 cm long tubes had significantly and consistently better height growth than the ones raised in 10 cm long tubes. The question which emerges is, 'Does the latest data available still support previous findings? It is not possible to use mean height data for it is based on varying plot numbers. The safeguard seems to be offered by using the number of green plots corresponding to a given treatment combination (Table 3). The Table shows that the number of green plots increase as age of the planting stock, and length of polythene tube increase. The influence of the planting seasons on the number of green plots is not clear cut. However, the need of raising the stock in 20 cm long is consistently emphasized by the fact that few green, many dried plots were planted with seedlings raised in 10cm long tubes.

Table 3. Number of green plots in a 4.3 year old *E. camaldulensis* facterial experiment of the interaction between stock size (age), Time of planting, and length of polythene tube at Nkurugano, Dodoma, Tanzania; as influenced by the indicated factors.

Factors			Number of Plots and Distribution				
Age	Season	Length		Greeen	Total green	Dried	Total Dry
4 months(C)	V	V	(a) 10Cm	2	6	10	18
			(b) 20cm	4		8	
8months(C)	V	V	(a)	4		8	
			(b)	3	7	9	17
12moths(C)	V	V	(a)	3		9	
			(b)	7	10	5	14
V	E.P.(C)	V	(a)	2		10	
			(b)	5	7	7	17
V	M.P.(C)	V	(a)	4		8	
			(b)	5	9	7	15
V	L.P.(C)	V	(a)	3		9	
			(b)	4	7	6	15

Factors				Number of plots and Distribution			
Age	Season	Length		Green	Total Green	Dried	Total Dry
V	V	10 cm(C)	E.P.	2		10	
		~~M.P~~	M.P.	4	9	8	27
			L.P.	3		9	
V	V	~~20 cm(C)~~	E.P.	5		7	
V	V	20 cm(C)	M.P	5	14	7	22
			L.P.	4		8	

Notes: C denotes keeping the factor constant
V denotes varying the factor
E.P. Early planting
M.P Mid planting
L.P Late planting.

Based on atecedent findings and a number of hints from Table 3, it seems reasonable to recommend that early planting of 12 month old stock raised in 20cm long polythene tubes as a standard nursery and planting out practice under Dodoma conditions.

3.1.2 Site preparation experiments

3.1.2.1 Species elimination trials

Assessments for species elimination trials Planted in 1980 are summarised in Table 4. It can be seen that Acacia nilotica seems

Table 4 Performance of 4.6 (a), 5.2 (b), and6.2 (c) year old tree species at the indicated sites in Dodoma District, Tanzania.

Species		~~Age~~ Assessment dates	Experimental Site Chimwaga S (%)	Chimwaga H (m)	Mlebe S (%)	Mlebe H (m)	Nkurugano S (%)	Nkurugano H (m)
Acacia nilotica	(a)	June 1984	-		32	0.90	66	1.61
	(b)	May 1985	-		31	1.20	65	1.81
	(c)	May 1986	-		Dried		41	1.20
Acacia tortilis	(a)		10	1.50	-		-	
	(b)		Dried		-		-	
Eucalyptus papuana	(a)		-		86	2.50	-	
	(b)		-		84	3.10	-	
	(c)		-		84	3.60	-	
Leucaena leucocephala I (Hawaiian Giant)	(a)		69	1.40	27	1.10	25	1.70
	(b)		51	1.57	Dried		20	2.20
	(c)		41	1.50	-		Dried	
L. leucocephala II ([illegible]aiian Ex-Morogoro	(a)		92	2.30	9	0.9	83	2.40
	(b)		65	2.88	Dried		23	1.82
	(c)		41	1.70	-		Dried	
L. leucocephala III (El-Salvador Ex-Longuza)	(a)		67	1.61	41	1.41	25	1.51
	(b)		45	1.84	Dried		23	1.62
	(c)		45	2.70	-		Dried	
Pithecolobium dulce	(a)		27	1.20	2	1.81	2	1.00
	(b)		Dried		Dried		Dried	

Notes: S - Survival H - Mean Height.

to be suited for the clay sites as manifested by Nkurugano. The performance of Eucalyptus papuana at Mlebe is of considerable interest as the trees show good vigour. However, a sudden drying of otherwise vigorous trees have been experienced at Mlebe several times. Caution, in the form of further observations has to be exercised. Viewed in relative terms, the performance of Leucaena leucocephala continues to indicate its relationship with soil texture. The predominance of the sand fraction at Chimwaga seems to favour the growth of the species. Nevertheless, as the species seeds profusely after two years, its potential role in land reclamation is considerable.

The performance of the tree species planted in 1981 is summarised in Table 5. With Exception of Eucalyptus microtheca and E. camaldulensis trials at Nkurugano, the other tree species tried, either dried or performed dismally.

Table 5. Performance of 3.6 (a), 4.3 (b) and 5.3 (c) year old tree species at the indicated sites in Dodoma District, Tanzania.

Species		Assessment dates	Experimental Site					
			Chimwaga		Mlebe		Nkurugano	
			S (%)	H (m)	S (%)	H (m)	S (%)	H (m)
Acacia aneura	(a)	June 1984	20	1.00	45	1.30	Dried	
	(b)	May 1985	9	2.60				
	(c)	May 1986	9	2.60	72	3.60*		
A. albida	(a)		Dried		Dried		Dried	
_. nigrescens	(a)		-		-		Dried	
A. pendula	(a)		-		-		Dried	
A. tortilis	(a)		Dried		17	1.32	Dried	
	(b)				17	1.98		
	(c)				17	2.80		
Eucalyptus camaldulensis	(a)		Dried		18	1.78	95	1.30
	(b)				17	2.40	87	1.68
	(c)				9	2.60	82	2.30
E. microtheca	(a)		Dried		21	3.12	72	1.30
	(b)				21	4.16	67	1.94
	(c)				11	3.90	67	2.30
E. paniculata	(a)		Dried		29	2.09		
	(b)				29	2.79		
	(c)				28	3.60		

Notes: * Beating up undertaken.

S - Survival, H - Mean Height.

3.1.2.2. <u>Site Preparation</u>

Decreases in Survival Continued. Nevertheless previous indications that ploughing, and ploughing and harrowing as the most superior site preparation techniques remain valid (Table 6).

Table 6. Performance of 5.3 year old <u>E. camaldulensis</u> plantings under different site prepatation methods at three sites in Dodoma District, Tanzania.

Land Preparation method	Number of Plots Green			Dried			Remaining Plots S (%)			H (m)		
	Ch	Ml	Nk	Ch	Ml	Nk	Ch	Ml	Nk	Ch	Ml	Nk
Manual	0	0	0	9	9	9	-	-	-	-	-	-
Ridging	0	3	0	9	6	9	-	26	-		2.72	-
Subsoiling	9	1	0	0	8	9	34	56	-	3.70	3.70	-
Ploughing	8	8	2	1	1	7	30	43	42	3.00	3.90	1.35
Ploughing & Harrowing	8	8	7	1	1	2	43	53	27	3.00	3.81	1.00

Notes: Ch - Chimwaga
Ml - Mlebe, Nk - Nkurugano
S - Survival; H - Mean Height.

3.1.2.3 <u>Termite Control</u>

ANOVA for the split plot experiment show that there is a significant difference in survival resulting from the quantities of Aladrin applied. The analysis did not cover the data for height growth as the main objective of the experiment was to investigate the effect of Aladrin application in the control of termites and this is directly linked to tree survival.

Table 7. Complete ANOVA table for a 3.3 year old Termite Control (in <u>E. camaldulensis</u>) experiment at Mlebe, Dodoma District, Tanzania.

Source	df	SS	MS	F
- Blocks	4	4436.48		
- Insecticide application in the nursery	1	16.82	16.82	0.0239 n.s
- Error Major Plot 4	4	2818.08	704.52	
- Aladrin levels	4	2521.68	630.42	2.3229*
- Insecticide X Aladrin levels	4	1542.08	385.52	1.4205 n.s
- Subplot error	32	8684.64	271.40	
Total	49	20019.78		

A comparison of treatment means (Snedecor and Cochran 1967, P.373) is presented as Table 8. The optimum level of application seems to be between 10 and 30 grams - possibly 25 grams.

Table 8. Comparison of treatment means of survival data% for the 3.3 year old *E. camaldulensis* termite control experiment at Mlebe, Dodoma District, Tanzania.

alandrin application	$\sqrt{Eb/b} = \pm 16.79$					Means
	Amount applied (g)					
	0	10	20	30	40	
Applied	46.4	45.8	47.2	52.0	48.8	48.0 $\sqrt{Ea/tb} = \pm 7.5$
Not applied	32.0	38.2	62.4	63.2	50.2	49.2
Total	78.4	84.0	109.6	115.2	99.0	
Mean	39.2	42.0	54.8	57.2	49.0	
	$\sqrt{Eb/nb} = \pm 4.66$					

3.1.2.4. Manuring

ANOVA tests do not reveal any significant survival and growth differences between the manuring regimes used. However, manuring seems to have stablized survival at all sites.

Table 9. Performance of *E. camaldulensis* under different manuring regimes at 3.6 (a), 4.3 (b), and 5.3 (c) years after planting at three sites in Dodoma District, Tanzania.

Treatment (Litres of Cow manure per planting pit)		Site					
		Chimwaga		Mlebe		Nkurugano	
		S (%)	H (m)	S (%)	H (m)	S (%)	H (m)
0	(a)	55	1.84	75	2.12	23	1.10
	(b)	55	2.45	57	3.55	22	1.25
	(c)	42	2.70	57	3.86	22	1.36
1	(a)	60	1.80	73	2.20	23	1.00
	(b)	58	2.41	66	3.23	23	1.24
	(c)	57	2.58	57	3.58	21	1.27
2	(a)	40	1.86	72	2.89	27	1.20
	(b)	38	2.46	52	4.05	25	0.97
	(c)	38	2.93	52	4.52	25	1.40
3	(a)	45	2.00	78	3.18	27	0.90
	(b)	44	2.61	70	4.40	14	1.24
	(c)	44	2.93	70	4.90	10	2.25
4	(a)	40	1.58	61	2.10	25	1.00
	(b)	37	1.09	52	3.76	24	1.37
	(c)	37	2.53	48	4.10	24	2.05

Notes: S - Survival, H - Mean Height

3.1.2.5 Live Hedges

Table 10 shows the performance of various live hedges. *Agave sisilana* is so far the best live hedge followed by *Dichrostachys cinerea*. Crown closure was not assessed as over 90 per cent of the crowns still open.

Table 10. Performance of various 3.3 year old live hedge plants at Mlebe, Dodoma District, Tanzania.

Species	Hedge	design	No. of Holes in Hedge Line (facing North): Inner No.	Inner Av. Hole size	Outer No.	Outer Av. Hole size	No. of over-lapping Holes	Hedge Plants: Survival% Inner	Survival% Outer	Mean Height(m) Inner	Mean Height(m) Outer	Inner Cassia siamea Plantings**: Survial(%)	Mean H(m)
<u>Dichrostachys cinerea</u>	Planting at 50cm spacing in two parallel lines	1 East	12	0.90	15	0.73	12(0.90)*	58	67	0.39	0.40		
		2 W	5	2.10	4	2.32	4(2.10)	69	67	0.46	0.50	80	1.75
		3 N	3	1.75	3	3.05	3(3.00)	66	49	0.48	0.50		
		4 S	2	1.46	2	1.35	2(1.50)	69	73	0.38	0.41		
			No. of Holes in Hedge: No			Average Hole Size (m)							
<u>Agave sisilana</u>		1 E	4			0.5		94		0.50			
		2 W	3			0.5		94		0.56		85	1.90
		3 N	2			1.0		89		0.80			
		4 S	1			0.5		97		0.78			
	Control		-			-		-		-		80	1.63

* Indicates average hole size in metres

** <u>Cassia siamea</u> was planted a year later.

3.1.3 Planting Techniques

3.1.3.1. Spacing trials

A further drop in E. camaldulensis plantings at Mlebe was recorded (Table 11). The Table seems to suggest that a suitable spacing regime for E. camaldulensis in 2.5 x 2.5 and 3.0 x 3.0 metres. This is due to the fact that survival drops before and after these spacing regimes. Howver this does not seem to agree with recommendation of spacings of 3.5 x 3.5m and above which were advocated by Nshubemuki and Maphole (1984, p.56)

Table 11. Performance of *Cassia siamea* and *Eucalyptus camaldulensis* under various spacing regimes at 2.3 (a), 3.3 (b) and 4.3 (c) years after planting at Mlebe, Dodoma District, Tanzania.

a

Spacing (m x m)		C. siamea		E. camaldulensis	
		Survival (%)	Mean Height (m)	Survival (%)	Mean Height (m)
1.5 x 1.5	(a)	25	1.80	47	2.31
	(b)	Dried		24	2.83
	(c)			24	4.08
2.0 x 2.0	(a)	17	2.70	44	2.20
	(b)	Dried		18	2.65
	(c)			18	3.48
2.5 x 2.5	(a)	23	2.40	65	2.40
	(b)	Dried		34	2.52
	(c)			34	3.67
3.0 x 3.0	(a)	16	1.41	57	2.26
	(b)	Dried		41	2.64
	(c)			41	3.48
3.5 x 3.5	(a)	19	1.58	24	2.05
	(b)	Dried		22	2.19
	(c)			8	4.00
4.0 x 4.0	(a)	14	2.00	36	2.45
	(b)	Dried		17	2.54
	(c)			14	3.15

3.1.3.2. Pit sizes

ANOVA for survival and height growth data could not be carried out for *Acacia nilotica* plots a Chimwaga as most of them dried at 4.0 years. Similarly, all *Acacia tortilis* plots at Mlebe dried, while all *Cassia siamea* plots at Nkurugano dried. ANOVA for the remaining plots show that various pit sizes did not influence survival and Height growth of Cassia siamea at Chimwaga (Table 12). Furthermore, significant differences in height growth for *Eucalyptus camadulensis* at 5.3 years are no longer distinguishable at 6.3 years (Table 13).

Table 12. Effect of planting pit size on survival and Height growth of 4.3 (a), 5.3 (b) and 6.3 (c) year old *Acacia nilotica* and *Cassia siamea* planted at Chimwaga, Dodoma District, Tanzania.

Pit Size (cm) (Width x Depth)	Age	A. nilotica S (%)	A. nilotica H (m)	C. siamea S (%)	C. siamea H (m)
15 x 30	(a)	20	1.69	56	2.12
	(b)	3	2.17	53	2.67
	(c)	2	2.10	53	2.74
15 x 30 with saucers	(a)	15	0.62	56	1.95
	(b)	6	1.10	52	2.40
	(c)	4	1.10	52	2.73
30 x 40	(a)	13	1.90	47	1.90
	(b)	10	2.38	44	2.46
	(c)	2	1.70	43	2.73
30 x 40 with Saucers	(a)	10	1.60	61	2.25
	(b)	7	2.14	59	2.75
	(c)	7	2.80	55	2.46
15 x 30 with trenches and ridges	(a)	14	1.00	60	1.67
	(b)	7	1.43	56	2.12
	(c)	7	2.10	56	2.66

S - Survival H - Mean Height.

Table 13. Performance of 5.3 (a) and 6.3 (b) year old *E. camaldulensis* at Mlebe, Dodoma District, Tanzania; as influenced by the indicated pit sizes.

Pit Size (cm) (Width x depth)	Age	Survival (%)	Mean Height (m)
15 x 30	(a)	42	4.51 a
	(b)	42	5.36
15 x 30' With Saucers	(a)	69	3.96 a
	(b)	64	4.75
30 x 40	(a)	59	4.46 a
	(b)	51	5.58
30 x 40 with Saucers	(a)	48	3.34 b
	(b)	48	3.99
15 x 30 With trenches and ridges	(a)	62	4.37 a
	(b)	46	4.09

$LSD_{.05}$ df 16 = 0.78m. The 4.3 year old assessments gave no significant differences.

3.1.3.3 <u>Time of Planting</u>

As reported earlier, for all species tried, survival is either zero, or below five per cent. The experiment is considered as a failure but the information it was expected to supply is given ~~in~~ by Table 2.

3.2 <u>Phase II Experiments</u>

Phase II experiments covered species and provenance trials; establishment techniques and fertilizer application to seedlings in the nursery. All species elimination trials and establishment technique experiments failed. The performance of provenance trials and the fertilizer application experiment are outlined hereunder.

3.2.1. <u>Provenance trials</u>

Table 14 shows the performance of the provenances tried. The Table amply shows that at 2.3 years, analyses of variance show no significant differences in survival but significant differences in height growth at two sites. Nkurugano trials failed.

3.2.2. <u>Fertilizer Application in the Nursery</u>

Analysis of variance reveals that there are significant differences in survival and height growth in 2.3 year old <u>E. camaldulensis</u> plantings at Mlebe (Table 15).

Table 15. Field performance of 1.3 (a) and 2.3 (b) year old E. camaldulensis plantings at Mlebe, Dodoma Tanzania as influenced by the NPK levels applied in the nursery.

Assessment Date	NPK levels (g) in potting mixture							
	0		30*		60*		60**	
	S	H	S	H	S	H	S	H
(a)	45.00d	1.69	76.00a	2.21	50.25c	1.67	55.00	1.57
(b)	45.00c	2.20c	76.00a	3.20a	50.25c	2.48b	55.00	2.45b

Notes: S- Survival (%) transformed. $LSD_{.01}$ df 9 = 0.51% (at 1.3, and 2.3 years).

H - Mean Height (m). $LSD_{.01}$ df 9 = 0.13m

* - Applied to 20 litres of soil mixture

** - An extra 60 grams sprinkled and mixed with top soil in the pots after 3 months.

: 14 :

Table 14: Performance of 1.3 (a) and 2.3 (b) year old Eucalyptus provenances at Chimwaga, Mlebe and Nkürugāno, Dodoma District Tanzania.

Species		*E. camaldulensis* Chimwaga S	H	Mlebe S	H	Nkurugano S	H		*E. microtheca* Chimwaga S	H	Mlebe S	H	Nkurugano S	H		*E. tereticornis* Chimwaga S	H	Mlebe S	H	Nkurugano S	H
Batch No.								Batch No.							Batch No.						
	(a)	16	0.85	n.p.		2	0.40		44	0.85	64	1.57	24	0.47		74a)**	2.33***	71	3.49	4	0.65
8963	(b)	16	1.00	n.p.		Dried		12172	44	2.48	64	2.60(b)*	Dried		11239	64	4.70(a)	38	4.67	Dried	
	(a)	41	1.12	49	3.02	8	0.50		59	0.78	74	1.69	42	0.50		62(a)	1.62	71	2.98	Dried	
12181	(b)	20	1.40	49	3.85	Dried		12811	52	1.18	74	2.88(a)	Dried		11583	60	4.11(b)	20	3.33	-	
	(a)	32	0.86	82	1.56	3	0.46		55	0.76	76	1.50	25	0.47		57(b)	2.05	53	2.45	12	0.50
12856	(b)	28	1.60	73	2.40	Dried		12816	55	1.38	66	2.00(c)	Dried		13301	55	4.20(a)	17	3.40	Dried	
	(a)	8	0.75	61	1.56	Dried			54	0.90	63	1.13	22	0.36		57(b)	1.66	58	1.92	16	0.57
13192	(b)	2	1.80	42	2.90	-		12818	54	1.60	63	1.60(d)	Dried		13349	50	3.61(c)	22	2.28	Dried	

Notes: n.p. - not planted

S - Survival (%)

H - Mean Height (m)

* - $LSD_{.05}$ df 16 = 0.24m

** $LSD_{.05}$ df 16 = 11%

*** $LSD_{.05}$ df 16 = 0.19m

4.0 DISCUSSION

Conceptions pertaining to this afforestation project in Dodoma revolved on water availability which is one of the major afforestation constraints. In semi-arid areas. This constraint may be overcome by: having knowledge leading to the manipulation of a number of climatic elements, raising suitable plants which are capable of withstanding water stresses, preparing planting sites in such a way that water losses (from rainfall) are minimised, and utilising planting techniques that will ensure maximum survival of plants. This report is therefore an ex extension of the findings summarized in Afforestation Research (Tanzania) - IDRC - MR 99 e; the two need be read together.

Knowledge of climatic data notably rainfall, offers guidelines on planting out operations. No definite recommendations in that regard were obtained in this study. However, enough data has been collected to warrant analysis of time series of monthly rainfall (Hay, 1974), or quartile deviations (Glantz and Katz, 1977), or use of a standardized anomaly index (Katz and Glantz 1985). A suggestion that future studies of rainfall characteristics in the semi-arid parts of Tanzania should preferably take that direction, is in no way a sophisticated form of ignorance which derives support from the keep trying approach, nor is it an underestimation of daunting task involved. A search of a measure or a group of measures that adequately predict rainfall variability in Dodoma gives valuable information the exploitation of which offers inroads in executing an effective afforestation programme.

Site preparation experiments

Site preparation experiments encompassed: Species elimination trials, evaluation of various ground preparation methods, termite control, manuring and live hedge experiments.

Acacia aneura, and *Eucalyptus papuana* (Tables 4 and 5 respectively) so far indicate promise as potential afforestation species. A revist of the initially impressive performance of *Leucaena leucocephala* (Sabas *et al*; 1982) now shows different results (Table4) even when allowance for dik-dik browsing et Chimwaga is taken into account. The results are disappointing both at Mlebe and Nkurugano possibly due to high pH at the latter site. It seems permissible to observe that the *Leucaena* varieties tried are incapable of withstanding adverse climatic conditions as witnessed in the 1981/82 and 1982/83 rainy season. The performance of 5.3 year old *E. microtheca* and *E. camaldulensis* at Nkurugano (Table 5) is satisfactory but this is at variance with the findings from provenance trials (Table 14). This can be atributed to differences on the orgin of seed.

However other experiments such as pit sizes, and manuring indicate the difficulties that should be expected when afforestation efforts are undertaken in the lower pediments which are represented by the Nkurugano site.

Reference to the site preparation methods used (Table 6) ploughing, and ploughing and harrowing appear as the most superior site preparation techniques. Howver, recorded survival is not spectacular although findings from Algeria (Monjauze 1960), ISRAEL (Seth, 1960) suggest the opposite. It seems that low survivals emanate from 'immediate' planting that followed ploughing. It has been later demonstrated in village plantations at Nkhome and Chamwino that ploughing the site a year before it is planted and reworking the soil just before planting, tends to increase survival. Similar results have been obtained in Nigeria (Iyamabo and Ojo, 1972). If this procedure is pursued in future plantings increases in survival Ceteris paribus, are expected. Subsoiling appears to be slightly superior to ridging. This is possibly due to the inherent nature of most of Dodoma soils which is the formation of a thin, impervions, surface cap after they have been ploughed or dug. The prospects of using ridging (and subsoiling) as a site preparation technique seem to have been thwarted by this soil characteristic. However, better performance would have been recorded had the ridges been tied; for the benefits of tie-ridging have been appreciated and proved useful under certain conditions in Tanzania (Prentice 1946, Peat and Prentice 1949); and in other semi-arid parts (Saeger et al; 1959). It follows therefore, that use of tie-ridges is likely to secure improvements. One of the oftenly recurring considerations in the evaluation of various site preparation techniques is their economic justification. This consideration can not simply be brushed aside. Yet when viewed in the context of afforestation of marginal sites the approach should be non-conventional in that the strategy should first aim at promoting survival of suitable tree species. If this is carried through the first rotation, subsequent rotations may not need elaborate site preparation techniques as there is little likelihood that coppicing shoots will dry. Such non intensive management practices will compensate for antecedent expenditure.

The termite control experiment (Table 7) shows significant differences resulting from the application of various levels of Alandrin, in 3.3 year old E. camaldulensis plantings at Mlebe. This is discordant with the findings of the first two assessments. The need of applying the insecticide in the nursery now seems to be justified by the data and partly by the need of preventing seedling damage in the nursery.

The manuaring regimes used seem to have stabilized survival at all sites. However, the influence was more beneficial for the Mlebe and to the lesser extent, the Chimwaga site; thus suggesting a beneficial effect of manuring if planting out is timed correctly. The low survivals recorded at Nkurugano seem to suggest the need of applying higher quantities of manure as soil moisture is tenaciously held in clay soils. The 'surplus' soil moisture resulting therefrom would be available to trees.

Although <u>Agave sisilana</u> appears, most likely as the more efficient live hedge than <u>Dichrostachys cinarea</u>. There is a need for both further observation and relating the findings to site. It can be recalled that the Agave, live hedge experiment at Nkurugano failed due to the fact that plants remained stunted thus indicating the likelihood that <u>Agave</u> is unsuitable as hedge plant for clay sites. A search for more livehedge plants that can be matched with a variety of sites is imperative.

<u>Planting techniques experiments</u>

These constituted two sets of experiments namely: spacing and pit size experiments.

Reference to the spacing experiment (Table 11), gives rise to two observations. Spacing seems to be species-specific for <u>Cassia siamea</u> plantings failed after 2.3 years while <u>E. camaldulensis</u> plantings continue surviving albeit marginally. Observations on spacing regimes raised earlier by Nshubemuki and Maphole (1984) remain valid here particularly when suitable site preparation methods are taken into account - Table 6 shows that manual site preparation methods do not promote survival, as the planting sites were prepared manually, failures are expected.

Although ANOVA tests indicate that various pit sizes do not significantly influence survival and height growth of <u>Casia siamea</u> at Chimwaga (Table 12), and in 6.3 year old <u>E. camaldulensis</u> at Mlebe (Table 13). The survivals recorded seem reasonable,. However, even with good survivals <u>Cassia siamea</u> does not attain satisfactory height at Chimwaga while height growth of <u>E. camaldulensis</u> at Mlebe is satisfactory. This seems to suggest that if <u>Cassia siamea</u> is to be grown for the production of poles, it should not be planted on hill slopes. However, its bushy appearance makes it well suited for land reclamation - contract with <u>E. camaldulensis</u>

Phase II experiments

Provenance trials and the fertilizer application experiment(in the nursery constitute Phase II trials reported here.

Provenance trials (Table 14) indicate that _E. microtheca_ seems to be suited for hills and their slopes (Chimwaga), and upper pediments (Mlebe) but poorly suited for the lower pediments (Nkurugano). _E. tereticornis_ seems to be well suited for hills and their slopes, barely suited for upper pediments and poorly suited for the lower pediments; whereas some _E. camaldulensis_ provenances appear well suited for the upper pediments. Extents of suitability however, are not clear cut as none of the growth parameters assessed consistently shew observed significant differences at different dates of assessment: either singly or in combination. This seems to cast a shadow of doubt aspecially in view of the fact that only four provenances were tested for each tree species. There is a lot of optimism concerning the afforestation potential of _E. camaldulensis_ provenances in Dodoma. A cautionary note as to be made particularly the deceptively simple classification of the species in two sub-species namely Northern and Southern populations. Turnbull (1973) proposed a provenance group classification based on eight geographic regions of occurrence based on the main drainage systems between which there was unlikely to be gene flow. Noting that generally the Northern populations of _Eucalyptus camaldulensis_ outrank the Southern populations, it is reasonable to suggest that Northern, _E. camaldulensis_ provenance groups should constitute future seed sources. Studies of the ecology and variation future trials involving with some modification may be extended to _E. microtheca_, and _E. tereticornis_; thus leading to the selection of suitable seed sources.

The fertilizer application experiment (Table 15) indicates somewhat consistently, that the optimum application of the NPK fertilizer in the nursery is 30 grams for 20 litres (one debe) of soil mixture. This is in contrast with reported successful potting mixtures which use ten times the quantity of NPK reported here (Procter, 1963). This is possibly due to the 1:1 clays which commonly occur in most of the landforms in Dodoma with exception of the lower pediments and flat land and valley floors (Nshubemuki, In preparation). As the cation holding capacity of 1:1 clays is lower than that of 2:1 clays, low NPK requirements are explained.

The points raised earlier on the economic justification of site preparation techniques are equally applicable here. However, the consideration which should not escape mention is the inducement of fast growth by the fertilizer after planting out which is by implication necessitates high water consumption. The outcome of these antagonistic tendencies is difficult to predict. It is possible that lack of sufficient soil moisture may retand growth rates. The prospect of inducing complete drying may be offset by the plant mechanisms used in withstanding water stress.

5.0 GENERAL CONCLUSIONS

The above experimental findings suggest intensive forest establishment and management techniques which will carry the trees through the first rotation. In this regard there is reasonable experimental evidence and clues that will later be subjected to further refinement as more scientific verification comes into light. The advocated establishment and management practices which have mainly surfaced from the first and second phases of the project are:

- The emergence of Eucalyptus papuana and E. microtheca as potential afforestation species, and the obvious need for continued species trials.

- Early planting of 12 month E. camaldulensis seedlings raised in 20cm long polythene tubes into which 25 grams of Alandrin, and 30 grams NPK have been added to every 20 litres of potting mixture promotes survival in the field.

- Field planting should be undertaken in ploughed and harrowed ground which is reworked regularly - preferably just before the rains.

- The optimum espacement regime varies between 2.5 x 2.5 and 4.0 x 4.0 metres. This obviously wide range is influenced by the species in question.

- No conclusive evidence has emerged from manuring levels and suitable pit sizes. However, it can be tentatively suggested that if manure is readily available,apply as much of it as possible, in 30 x 40cm pits.

- Of the promising Eucalyptus provenances, there are some indications that E. microtheca and E. tereticornis are suited for hills and their slopes and upper pediments. Meticulous selections (from Northern populations) are needed when selecting seed sources for E. camaldulensis.

- The protection of trees (from livestock damage) is expected to be provided by Agave sisilana. However a further live hedge - site serarch should be undertaken.

Employment of such practices will obviously raise the expenditure stakes in the entire outlay. However, these will be offset by the yield from subsequent coppice stands. A further justification for such intensive management practices the protection of soils from water and wind erosion.

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