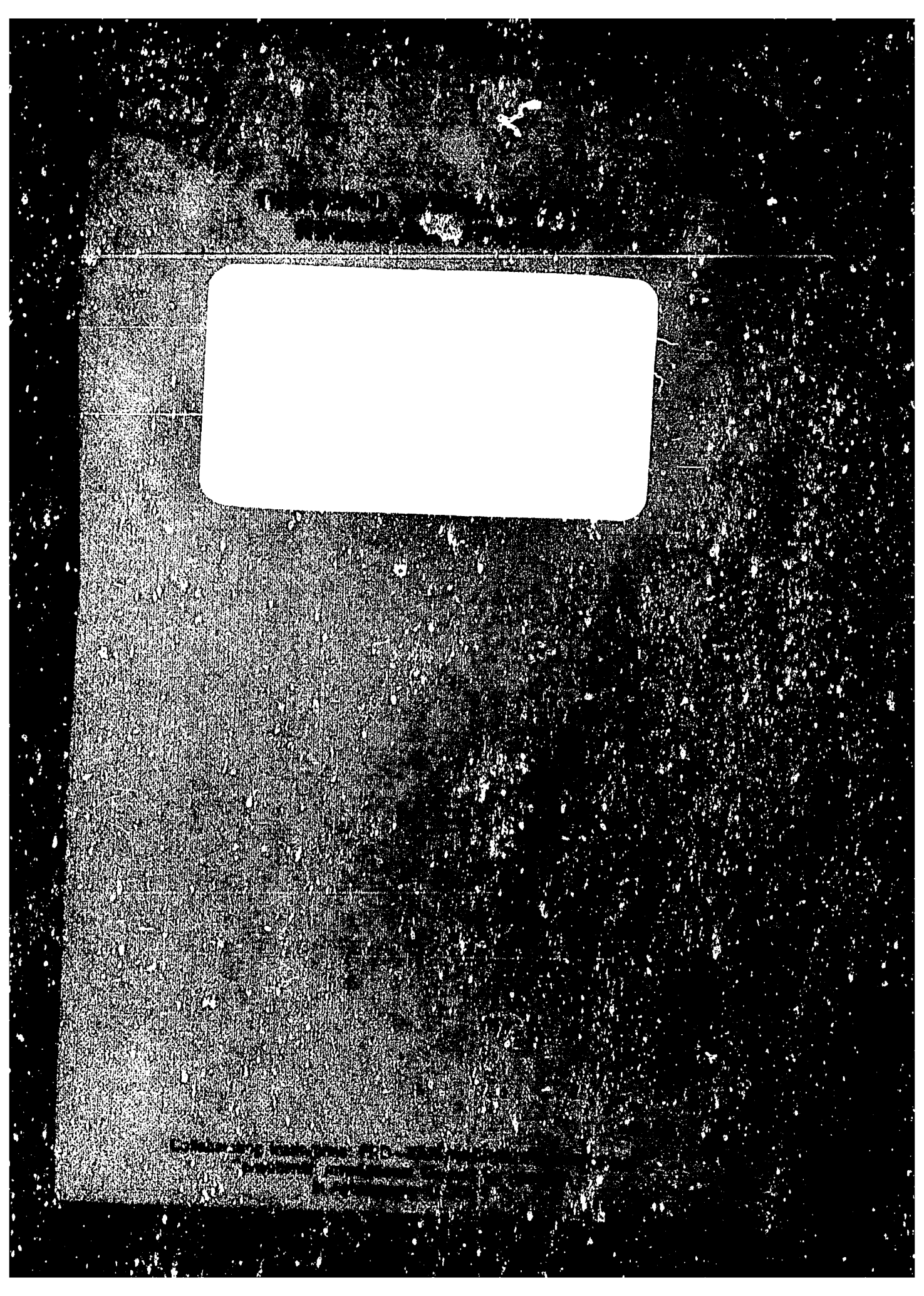

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REHABILITATION OF BALANITES AEGYPTIACA, ACACIA TORTILIS AND COMMIPHORA AFRICANA IN THE GRAZING LAND: PRELIMINARY RESULTS

RESEARCH REPORT NO. 2

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1985

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ACKNOWLEDGEMENTS

The authors wish to acknowledge the help extended by the Director of ICRAF in authorizing the use of Council facilities ranging from office space and secretarial services to computer facilities.

The word processing services rendered by Ms. Jane Ngeene are deeply appreciated. Sincere gratitude is also extended to Project staff, especially Mr. Ezekiel Kyalo, the field technician, for his dedicated surveillance of the experiment.

This project has been made possible by financial assistance from IDRC to the Government of Kenya.

1. INTRODUCTION

The Dryland Agroforestry Research Project sited in Machakos District aims at developing agroforestry technologies for the semi-arid areas of Kenya and other East African countries with a view to improving the quality of the life of the inhabitants. The following are the main research objectives:

- To examine the possibilities for maintaining/increasing the productivity of the cropping system by establishing an alley cropping system.

- To examine the possibilities for improving the quality, quantity and seasonal distribution of forage on the farm by planting fodder tree/shrub species in the grazing areas and by developing cut-and-carry forage systems;

- To examine the possibilities for reducing the labour input requirements of the free-grazing system and fuelwood collection by establishing live fences around the grazing land, and on-farm fuelwood tree planting.

- To examine the possibilities for increasing the cash income of the farmers by the introduction of fruit trees.

A survey of the existing vegetation in the grazing land revealed a wealth of browsed, naturally regenerated tree seedlings/stumps (herein after referred to as trees). Although several years old, most trees never grow to maturity because they are constantly browsed by domestic animals and wild life. Another factor impeding the growth of these trees is the low water infiltration rate into the soil caused by high run-off due to lack of vegetation and compaction of the topsoil.

This research report deals with experimentation on the improvement of the existing tree vegetation in the grazing land with the ultimate aim of improving the future quantity, quality and seasonal distribution of fodder as well as increasing the future quantity of farm fuelwood.

The experiments are being conducted on farms in the Kakuyuni catchment area which is in the eastern part of Machakos District, about 140 km from Nairobi. The climate in the area is described as semi-arid, with an average bimodal annual rainfall pattern totalling 600 mm. The predominant soil types are the red ferrasol-cambisols (including lithic and bouldary phases), while the very dark greyish brown to black vertisols (commonly known as black cotton soils) are found in depressions. The catchment's altitude is about 1200 m.

After a brief inventory of the existing vegetation in the catchment area, Balanites aegyptiaca, Acacia tortilis and Commiphora africana were selected for experimental purposes.

Acacia tortilis is browsed by goats, while the pods are eaten by goats and cattle. Furthermore, the trees provide fuelwood and fencing material.

Balanites aegyptiaca is browsed by goats, which also eat the fruits. The trees also provide fencing material and construction wood.

Commiphora africana is browsed by goats and provides fencing material.

2. DESCRIPTION OF THE EXPERIMENT

Twenty-three (23) farmers were selected to participate in the experiments. An inventory of the 3 selected species was made on each of these farms and, based on this information, it was decided for each farm to experiment with either 1, 2 or 3 species (normally 2 per farm).

Twenty (20) trees of each selected species were randomly chosen per farm. Ten (10) of these were monitored for control purposes (exposed to browsing) while the remaining ten were treated and monitored.

The experiment corsisted of the following treatments:

- Digging of a small V-shaped micro catchment upslope from the tree (see Annex 1).
- Pruning of the tree to one main branch, which was supported if necessary. This treatment was repeated twice.
- Protection of the tree with a ring of thorny branches.

The direct aim of the experiment is to examine whether or not this "best bet" combination of treatments will allow the treated trees to develop an apical shoot which can be out of reach of domestic animals/wildlife within a relatively short time. The underlying hypothesis is that when such shoots develop into mature trees, the potential future fodder and fuelwood production will be higher than from the present vegetation of browsed trees.

The root collar diameter at soil level (in mm) and height measurements* of the main branch were taken at the start of the experiments, i.e., October 1983, after three months in January 1984, after another sixth months in July 1984, and finally in April 1985.

*It should be noted that the main branch could change during the duration of the experiment, especially if the branch initially selected died.

It should be noted that the difference in incremental growth between treated and control trees should not be considered as a measure of additional fodder and/or fuelwood during these periods because part of the incremental growth of the controlled trees is browsed by animals.

Besides these physical measurements, notes were made on the soil characteristics around each tree, using the following classification:

ferrasol-cambisol (red)	-	shallow (lithic phase)	1
	-	deep	2
vertisol (black)	-	deep	3

3. OBSERVATION AND RESULTS

3.1. General Observations

3.1.1. Rainfall

The experiment started in November 1983 (t_0), and over the first three- month period up to the second measurement (t_1) in January 1984 rainfall was 173.75 mm (spread over 19 days). From the second to the third measurement (t_2), rainfall totalled 192.5 mm spread over six days including two freak storms of 103 mm and 55 mm, respectively. This second six-month measuring period may therefore be characterised as a period of drought in which all annual crops failed. The last measurement (t_3) took place in the middle of April and rainfall over this 8 to 8.5-month third measuring period totalled 779.4 mm, distributed over 40 days.

3.1.2. Labour requirements

The micro catchments were dug while the soil was still hard, because of lack of rain. It was observed that one man could dig about 40 micro catchments in an 8-hour working day using a jembe (local hoe). Digging catchments on black cotton soils was found to be harder than on the red soils.

The protection of the trees with thorny branches collected from the surrounding area required 1 menday for about 60 trees. Labour requirements for this activity do, of course, vary with the distance from which the thorny branches have to be collected. If family labour is engaged for the digging of micro catchments and the protection of the trees, the opportunity cost of such labour is close to zero, since the whole operation can be scheduled at a time and a speed which do not interfere with other farm activities.

3.1.3. Effectiveness of the protective measures

Although some browsing did take place, in general, the thorny branches provided adequate protection for the treated trees.

Difficulties did arise, however, when excessive height growth caused the rather thin apical shoots to bend, thereby bringing them within reach of browsing goats.

It was furthermore observed that the maintenance of the protective ring depended very much on the species used for protection. Acacia tortilis branches were found to last only 3 to 4 months (termites), while Acacia melifora easily lasted up to 1 year.

It was furthermore observed that, as a result of the protective measures and the increased water infiltration, there was a marked increase in plant species in and around the catchment area.

3.1.4. Effectiveness of V-shaped micro catchment

The positive effect of the micro catchments in terms of increasing soil moisture infiltration around the trees was already shown in Ssekabembe's trials (1984)[1]. Not only does it increase soil moisture at deeper levels, but it also enables the trees to enjoy soil moisture over a longer period.

It was observed, however, that many of the catchments silt up as a result of the erosion taking place in the grazing land.

3.1.5. Farmers' reaction to the experiment

Farmers were sceptical about doing "something" with the existing vegetation. They like to think of projects bringing new trees. Recently more farmers have requested to participate.

Furthermore, farmers have also started to ask questions about the future management of the trees.

3.2. Statistical Treatment of Data

The analysis of the data was computerised, using ABSTAT, a commercially available software package. Trees which died or were cut by the farmer during the duration of the experiment were omitted from the analysis. Analysis was done on the basis of soil classification as well as root collar size where size (1) consisted of those trees with less than overall mean diameter for both control and treated while class (2) consisted of those above the overall mean.

T-tests were used to check whether or not differences between means were statistically significant. The following symbols are used to signify the level of significance:

*** - significant at 1% level
* - significant at 5% level.

1 - Charles Ssekabembe, Research Fellowship 1983/1984 Final Report

3.3 Experimental Results

3.3.1 Balanites aegyptiaca

A total of 320 trees distributed over 16 farms were monitored (50% treated, 50% control). Eleven (11) of the treated trees and 13 of the control trees died or were removed by the farmers during the experimental period.

The root collar diameter and height measurements are summarised in Table 1.

Height growth of all the treated trees was significantly higher than of the control trees (T-value 6.59***; df 194).

A comparison of height growth of treated trees over 3 different soil types indicates that total height growth was highest on the red shallow soils, i.e. 73.53 cm, followed by the deep red soils i.e., 54.61 cm, while height growth on the black cotton soils was lowest, i.e., 43.80 cm. (T-value between red shallow and black cotton 2.18*; df 40).

There was very little difference between total height growth of small-sized trees (root collar size 1) and large-sized trees (size 2), i.e., 54.78 vs 56.96 cm.

A clear difference can be observed between the height growth of the treated trees during the second (dry) period and the third (wet) period. It is interesting to note, however, that the effects of the drought seem to be felt most on the black cotton soil and least on the red shallow soil, i.e., 7 cm vs 24.89 cm growth, while the trees with a smaller root collar are affected more than the larger ones. These indications are however not statistically significant.

Root collar diameter growth of all treated trees was only marginally higher than of the control trees.

Differences in root collar growth of treated trees between different soil types were small and statistically not significant.

However, root collar diameter growth of the smaller trees (size 1) was significantly higher (44%) than that of the larger trees (T-value 2.28*; df 145).

As for the height growth, a significant difference in root collar diameter of the treated trees can be observed between the second and the third measuring period as a result of the drought in period 2 (T-value 7.13***; df 296). It is interesting to note, however, that the root collar growth of the control trees suffered consistently less than of the treated trees. This seems to suggest that height growth of treated trees during a drought period takes place partly at the expense of the root collar

Table 1 : Summary results root collar diameter and height growth B. aegyptiaca

	all observation		soil type* 1		2		3		root collar size** 1		2	
	control	treated	control	treated	control	treated	control	treated	control	treated	control	treated
	n=147	n=149	n=48	n=21	n=74	n=107	n=25	n=21	n=57	n=81	n=90	n=68
Initial height (cm)	71.86	58.69	73.23	48.71	74.95	60.39	60.06	59.98	49.69	46.28	85.90	73.46
Initial rootcollar(mm)	19.86	15.99	21.18	15.68	20.09	16.87	16.66	11.79	10.17	10.20	26.00	22.89
Incremental height growth(cm)												
period 1	4.47	13.70	3.05	16.07	4.83	14.64	6.11	6.50	1.04	11.34	6.64	16.50
period 2	7.36	14.88	2.94	24.88	9.18	14.46	10.42	7.00	3.82	11.49	9.59	18.92
period 3	9.03	27.18	18.23	32.58	2.03	25.51	12.12	30.30	15.54	31.95	4.91	21.50
Total	20.86	55.76	24.22	73.53	16.04	54.61	28.65	43.80	20.40	54.78	21.14	56.96
in percentage	29%	95%	33%	151%	21%	90%	48%	73%	41%	118%	25%	77%
Incremental root collar growth(mm)												
period 1	1.38	1.39	1.71	1.11	1.21	1.39	1.24	1.68	0.96	1.37	1.64	1.42
period 2	1.81	0.84	2.63	0.18	1.10	0.90	2.37	1.24	1.89	0.82	1.76	0.86
period 3	2.63	4.62	3.18	5.90	2.97	4.43	0.55	4.30	3.35	5.78	2.17	3.24
Total	5.82	6.85	7.52	7.19	5.28	6.72	4.16	7.22	6.20	7.97	5.57	5.52
in percentage	29%	43%	35%	45%	26%	40%	25%	61%	61%	78%	21%	24%

*Soil type 1 shallow red ferrasol - cambisol
2 deep red ferrasol - cambisol
3 black cotton soil

**Root collar diameter 1 initial < average (15,99 mm)
2 initial > average

growth. Furthermore, root collar growth of the treated trees on the 3 soil types during this drought period resulted in an opposite ranking height growth, i.e. root growth was lowest on the red shallow soil and highest on the black cotton soil, while height growth was highest on the red shallow soils and lowest on the black cotton soil.

In relative terms (dh/dr) root collar growth on the red soils was more seriously affected by the drought than the height growth. The same could not be observed for the treated trees on the black cotton soil.

Die back of the apical shoots took place on 7 trees on the deep red soils, 5 trees on the black cotton soils and 1 on the red shallow soils.

Browsing took place on the 8 treated trees on the deep red soils and on 1 tree on the shallow red soil.

3.3.2. Acacia tortilis

A total of 280 trees distributed over 14 farms were monitored (50% treated, 50% control). During the experimental period 6 treated trees and 19 control trees died or were removed by the farmer.

The root collar diameter and height measurements are summarised in Table 2.

Total height growth of all the treated trees was significantly (158%) higher than for the control trees (T-value 6.29***; df 253).

A comparison of the height growth of treated trees over the 2 soil types showed a better growth on the deep red soils than on the red shallow soils (T-value 2.43*, df 127). Little difference in total height growth was observed between the 2 root collar size classes.

Height growth during the third period was very low, especially when considering the much better rainfall condition (as compared to period 2). The main cause of this poor performance is the fact that several (16) apical shoots, which developed during the second period, died. No explanation could be offered for this phenomenon. It was also observed that the very fast initial height growth, i.e., 45.48 cm, over periods 1 and 2, resulted in many apical shoots bending over, thereby bringing them within reach of browsing goats. By the end of period 3, the number of trees recorded as browsed numbered fourty (40).

Total root collar diameter growth of treated trees was 54% better than of the control trees (3.98***; df 253).

Little difference in root collar growth of treated trees was observed between the different soil types and root size catego-

Table 2 : Summary results root collar diameter and height growth A. tortilis

	all observation		soil type 1		soil type 2		root collar size 1		root collar size 2	
	control	treated	control	treated	control	treated	control	treated	control	treated
	n=121	n=134	n=45	n=19	n=75	n=110	n=53	n=76	n=68	n=58
Initial height (cm)	99.21	92.99	105.48	105.32	95.01	91.38	80.75	81.41	113.59	108.17
Initial root collar (mm)	14.94	14.20	15.06	14.16	14.86	14.21	10.24	10.80	18.59	18.66
Incremental height growth (cm)										
period 1	2.03	19.64	1.18	15.5	2.80	20.32	-0.33	19.00	3.88	20.48
period 2	5.85	25.84	- 0.30	15.29	8.68	28.17	0.47	24.71	10.03	27.31
period 3	15.89	16.04	13.15	6.53	17.61	17.95	15.29	13.92	16.35	18.81
Total	23.77	61.52	14.03	37.32	29.09	66.44	15.43	57.63	30.26	66.60
in %	24%	66%	13%	35%	31%	73%	19%	71%	27%	61%
Incremental root collar growth (mm)										
period 1	1.26	2.18	1.04	2.71	1.35	2.12	1.11	2.49	1.37	1.77
period 2	1.23	1.84	0.95	1.57	1.32	2.02	0.92	2.06	1.46	1.54
period 3	3.06	4.83	2.24	5.19	3.49	4.83	2.63	4.59	3.39	5.14
Total	5.55	8.85	4.23	9.47	6.16	8.97	4.66	9.14	6.22	8.45
in %	37%	62%	28%	67%	41%	63%	43%	85%	33%	45%

Soil type 1 shallow red ferrasol - cambisol
2 deep red ferrasol - cambisol
3 black cotton soil (too few observation)

Root collar diameter 1 initial < average (14,20 mm)
2 intial > average

ries.

The root collar growth during the second period was seriously affected by the drought. It should be noted, however, that the control trees suffered more than the treated ones, implying that the incremental height growth during this period does not take place at the expense of the root collar diameter growth.

3.3.3. Commiphora africana

A total of 80 trees, distributed over 4 farms, were monitored (50% control, 50% treated).

During the experiment, 3 control and 1 treated tree died or was removed by the farmer.

Total height growth (47.61 cm) of the treated trees was significantly higher than the almost zero growth of the control trees (T-value 6.80***; df 74). Evidently the latter trees have been heavily browsed.

No big difference in height growth of treated trees was observed between the 2 soil types, nor between the two root collar size categories.

While the treated trees on the red shallow soil responded predictably during the drought period (lower growth), the treated trees on the deep red soils seemed to respond in the opposite direction, i.e. height growth period 3 less than in period 2. However, the latter is explained by the fact that incremental height growth of the treated trees on the deep red soils resulted in rather weak apical shoots which did bend and were browsed by goats (observed on 18 trees). A similar growth development was observed on the treated trees with the smaller initial root collar size.

Total root collar diameter growth of the treated trees was also significantly higher (70%) than of the control trees (T-value = 2.80***; df 74).

Total root collar growth of treated trees on the deep red soils was about 80% better than on the shallow red soils (T-value 2.02*; df 37), while total root collar growth of the smaller treated (size 1) was about 50% higher than that of the larger trees.

The effect of the drought on root collar growth in period 2 (as compared to period 3) is not uniformly evident. It was observed on the treated trees on the deep red soils as well as the treated trees with root collar size 1, but the opposite seems to be true for the trees on the red shallow soils and the larger trees (size 2), i.e, root collar growth during the third period is less than that recorded in the second period. It is interesting to note that this is exactly the opposite from the height growth.

Table 3 : Summary results root collar diameter and height growth C. africana

	all observation		soil type 1		soil type 2		root collar size 1		root collar size 2	
	control	treated	control	treated	control	treated	control	treated	control	treated
	n=37	n=39	n=26	n=11	n=11	n=28	n=15	n=20	n=22	n=19
Initial height (cm)	68.38	55.79	66.54	52.81	72.74	56.96	55.47	52.2	76.95	59.47
Initial root collar (mm)	26.59	22.83	26.01	26.54	27.73	21.49	15.80	17.47	34.18	28.47
Incremental height growth (cm)										
period 1	1.94	13.40	1.23	7.18	3.64	15.84	0.73	16.83	2.77	9.79
period 2	-1.97	17.29	-0.31	15.00	-5.91	18.20	0. 86	16.38	-3.91	18.26
period 3	3.22	16.92	6.19	27.18	-3.82	12.89	7.13	12.60	0.55	21.47
Total	3.19	47.61	7.11	49.36	-6.09	46.93	8.72	45.81	-0.59	49.52
in %	4.67%	85.34%	10.68%	93.47%	-8.37%	82.39%	15.72%	87.76%	-0.77%	83.27%
Incremental root collar growth (mm)										
period 1	1.24	2.45	1.35	1.58	0.98	2.79	1.17	3.04	1.29	1.84
period 2	0.66	2.39	0.69	2.84	0.71	2.22	1.31	2.01	0.21	2.80
period 3	3.17	3.70	3.61	1.04	2.10	4.74	2.95	5.26	3.31	2.06
Total	5.07	8.54	5.59	5.46	3.79	9.75	5.43	10.31	4.81	6.75
in %	19.07%	37.40%	21.49%	20.57%	13.67%	45.37%	34.37%	59.01%	12.28%	23.71%

Soil type 1 shallow red ferrasol - cambisol
2 deep red ferrasol - cambisol
3 black cotton soil

Root collar diameter 1 initial < average (22.83 mm)
2 initial > average

The table also shows clearly that root collar growth of the treated trees during the period of drought suffered less than that of the control trees.

4. SUMMARY AND CONCLUSIONS

The experiments aimed at increasing the growth of the existing vegetation gave varying results with the different tree species.

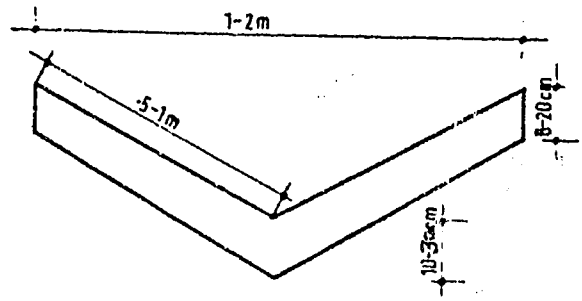
Balanites aegyptiaca responded favourably to the treatments, especially on the shallow red soils. Over the 18-month period, height increased by 55.76 cm, while root collar diameter increased by 6.85 mm. While most trees are still too small to leave them unprotected, there seems to be little doubt that the apical shoots are steady enough to continue their growth into mature trees.

Although the total height and root collar growth of the Acacia tortilis was almost the same as Balanites trees, i.e., 61.52 cm and 8.85 mm respectively, the die back of the apical shoots during the last measuring period raises serious questions as to the appropriateness of this treatment. Furthermore the firmness of the apical shoots leaves much to be desired. It is therefore suggested that the treatments for the Acacia tortilis trees should be modified, i.e. hence several shoots develop instead of just one so as to avoid too fast a growth of the apical shoots.

Commiphora africana's response to the treatments was somewhat in between those of the Balanites and the Acacia. Height growth was 47.61 cm while root collar growth was 8.54 mm. The firmness of the apical shoots, especially those which had developed quickly on the deep red soils and those which initially had a below-average root collar diameter, was insufficant to keep them upright. It is therefore also recommended to modify the treatment in the same way as for Acacia tortilis.

ANNEX 1

The approximate dimensions of the V-shaped micro catchments used are shown below.



Based on some earlier studies on soil moisture, catchments were positioned about 10 to 20 cm above the trees.