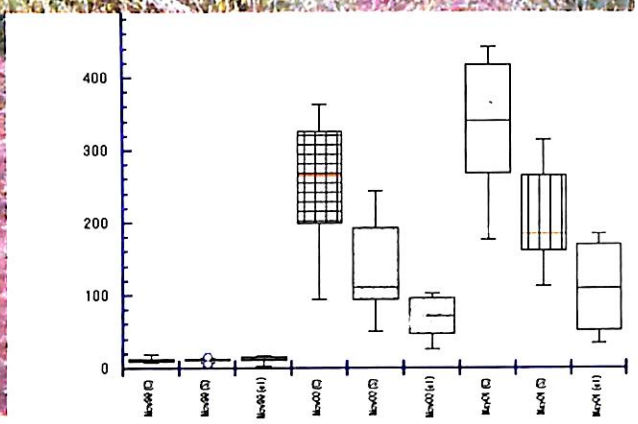
SOFEM Technology development

(preliminary result)

- **Verify practical technology by on-farm experiments**
- **Development of basic tree planting technologies**



(Draft)

Farm Forest establishment (technology)

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General information

This document (**SOFEM technology development I**) is one of the three documents produced by farm forest establishment (technology) section of SOFEM Project. The document is comprised of reports of trials conducted by farm forestry establishment (technology) section.

This document gives detailed results of individual on-farm experiment (water-catchment, hole size, site preparation, weeding, pruning, Melia planting site, growth rate comparison) and some basic tree planting technology development trials (seed germination of *Melia volkensii* and *Terminalia brownii,* and termite control).

The other two documents are

SOFEM technology development II
SOFEM technology development III

SOFEM technology development II

- **On-farm experiment**
- **Germination test**
- **Root system development**
- **Termite control**

This document shows the summary of individual on-farm experiment and some basic tree planting technology development trials.

1. The contents of the individual onfarm experiment are as follows.
   - A summary paper of each onfarm trial (Objective, Site description, Treatment, Progress, Results, Related report, etc.)
   - The picture of each trial plot
   - The line graph of each trial sites (Survival rate, Height, DGH diameter)
2. The contents of some basic tree planting technology development trials are as follows.
   - A summary paper of each trial (Objective, (Site description,) Treatment, Progress, results, Related report, etc.)
   - The picture of each trial and/or some reference materials.

For details of Root system survey results, see the "Root pattern of some tree species in semi-arid area".

3. Summary data of the onfarm trial.

SOFEM technology development III

Summary of on-farm experimental sites

This document shows the summary of each onfarm trial site and its progress.

The contents of this document are as follows.

1. Catalogue of on-farm experimental sites.
    - Location and area of each on-farm trial sites.
2. Location map.

3. Summary of each on-farm experimental site.
    - A summary paper of each on-farm experimental site (farmer's name, Trial items, Planted species, Site description, Progress, Results, Demonstration effect, etc.)
    - Plot design of each on-farm experimental site.
    - Soil profile description of each on-farm experimental site.
    - The picture showing progress of each on-farm experimental site (each trials and growth rate comparison trial).
4. Rainfall data within the project operation area (15 on-farms/ 12 farm forests and Tiva/Kitui center)

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Outline of the on-farm trials in SOFEM project

1 Introduction

Tree planting technologies for Arid and semi-arid (ASALs) have been developed in on-station trial sites at Tiva Pilot forest, but those technologies were developed in the specific site by heavy machines like bulldozers which were used to prepare the trial sites. So, the developed technologies in the Pilot forest cannot be adopted directly by the farmers because of the limitation of the farmers' facilities and labor, which they can allocate for farm forest establishment activities. The verified technologies developed in the pilot forest were,

1) Water catchment (V-shape, W-shape, control) (P.O.1.2.2.1)
2) Site preparation (oxen plough, hand tilling, control) (P.O.1.2.2.2)
3) Hole size (20 x 20cm, 45 x 45cm, 60 x 60cm) (P.O.1.2.2.3)
4) Weeding (complete weeding, spot weeding, slashing) (P.O.1.2.2.4)
5) Pruning (1/2 of height, 2/3 of height, control) (P.O.1.2.2.5)
6) Feed back from the farm forest (P.O.1.2.2.6)

Establishment of fruits and fodder trees were also integrated in the on-farm trial (P.O.1.2.3.1)(P.O.1.2.3.2)

So, to extend the developed technologies to the farmers, the verification of those technologies is required under different condition (rainfall amount, soil type). These involve modification of the developed technologies to suit farmer's condition and resources. During the verification, farmers use their own skills. Technology development section of the SOFEM has conducted verification of these technologies with farmers in the project area

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2 Objectives

1) To apply and verify technologies developed in the pilot forest under different farmland conditions.
2) To demonstrate these technologies to the nearby farmers for future adoption.

Methods

(1) Three farmers were selected for on-farm trials in 1998, six in 1999 and six in 2000. The criteria that were considered in selecting the farmers were;

1. willingness of the farmer to collaborate with the project,
2. availability of enough land which could be used for the trials,
3. location of the area, agro-climatic zone,

The on-farm trial sites were established by using the popular species such as *Melia volkensii, Azadirachta indica* and *Grevillea robusta.*

Except for treatments all the trial species and planting method were maintained as follows.

trial species*Azadirachta indica**Grevillea robusta**Melia volkensii*
and *Senna siamea*(only for buffer *Terminalia brownii*)

1. method oxen-plough
   hole size 45cm x 45cm
   spacing 3.5m x 3.5m
   W-shaped micro-catchment (V-shaped in 1998,1999)
   complete weeding

(2) The growth rate comparison experiments were set on all 15 on-farm trial sites in 2000.

trial species*Melia volkensii* and *Senna siamea*

2. method oxen-plough
   hole size 45cm x 45cm
   spacing 3.5m x 3.5m
   W-shaped micro-catchment
   complete weeding
3. inter-cropping maize 2 lines/ beans 1 line between the trees

(3) Survival rate and growth parameters (height and root color diameter) were taken after every three months. Monitoring was conducted every month.

(4) Farmers were requested to do weeding, protection and repair of broken micro-catchments. However, some of the farmers (especially teacher) could not apply fully the required treatments, and therefore project workers assisted in 70% of the on-farm trial sites management.

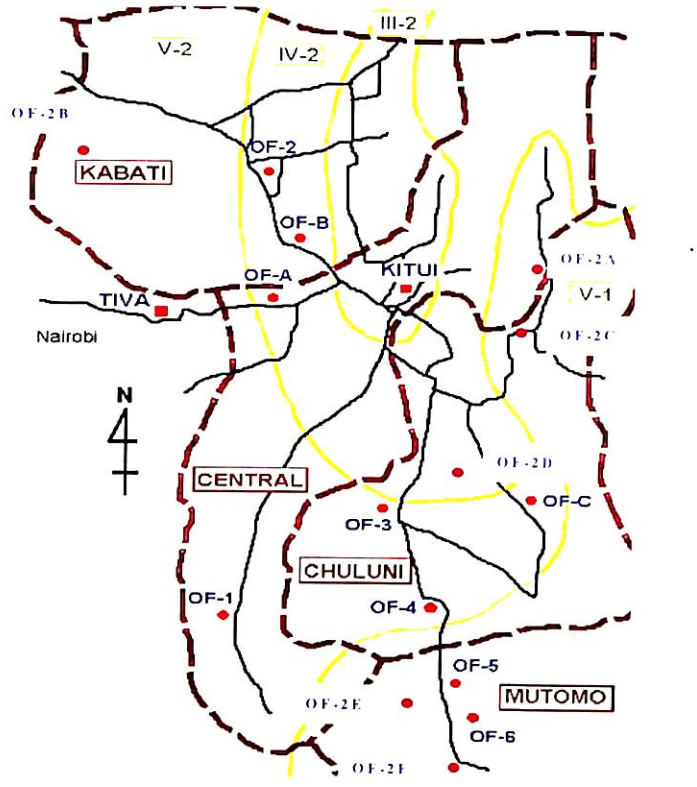
(5) From February 2001 to June 2001 project provided barbed wire to all the trial sites for protection considering the importance of the experiments conducted in those trial sites.

4.. Outline of the trial sites

Outline of the on-farm trials sites

Establised Year	Trial Site Name	Division	Agro-climattic zone	Soil type	Verified technology
1998	OF-A	Central	-2	Luvisols	Water catchment
	OF-B	Kabati	-2	Regosols	Hole size
	OF-C	Chuluni	-2	Cambisols	Site preparation
1999	OF-1	Central	-2	Luvisols	Fodder
	OF-2	Kabati	-2	Luvisols	
	OF-3	Chuluni	-2	Cambisols	
	OF-4	Chuluni	-2	Luvisols	Weeding
	OF-5	Mutom	-1	Luvisols	
	OF-6	Mutomo	-1	Luvisols	Water catchment
2000	OF-2A	Central	-1	Luvisols	Pruning
	OF-2B	Kabati	-2	Vertisols	Hole size
	OF-2C	Chuluni	-1	Luvisols	Melia planting site
	OF-2D	Chuluni	-2	Acrisols	Water catchment
	OF-2E	Mutomo	-1	Ferralsols	Site preparation
	OF-2F	Mutomo	-1	Luvisols	WeedingPruning

Note; The growth rate comparison trials were set on all 15 on-farm trial sites in 2000.



Results

(1)The following table shows the summary of the result of ANOVA analysis.

The result of ANOVA analysis of on-farm trials (June 2001)

Establish Year	Site Name	Agro-climattic zone	Verified technology		Summary
1998	OF-A	-2	Water-catchment		Significant difference between V/control
			Hole size	×	
			Site preparation	×	
	OF-B	-2	Water-catchment		(affected by soil fertility/browsing)
			Hole size		(affected by soil fertility/browsing)
			Site preparation		(affected by soil fertility/browsing)
	OF-C	-2	Water-catchment		Significant difference between W/control
			Hole size	×	
			Site preparation		(control plot is bigger than others)
1999	OF-4	-2	Weeding		
	OF-5	-1	Weeding		
	OF-6	-1	Water-catchment-S		Significant difference between V/control
			Water-catchment-A	×	
2000	OF-2A	-1	Pruning	×	
	OF-2B	-2	Hole size	×	
	OF-2C	-1	Melia trial	×	
	OF-2D	-2	Water-catchment		(control plot is bigger than others)
	OF-2E	-1	Site preparation		(control plot is bigger than others)
	OF-2F	-1	Weeding		
			Pruning	×	

(note) The meanings of the each mark are in the following.

; significant difference confirmed clearly.

; In some case, significant difference confirmed.

; In some case, significant difference confirmed, but affected by another factor.

×; significant difference was not confirmed.

(2)Problems for data analysis

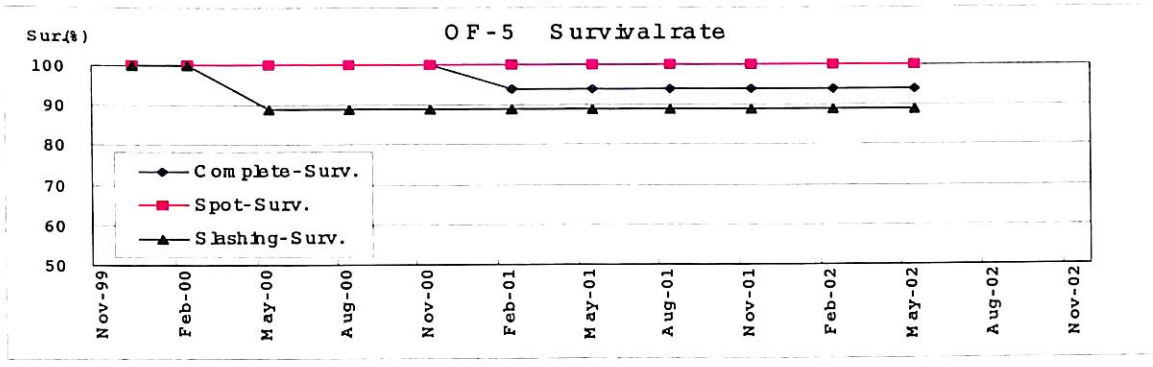
Some trial sites were severely browsed by livestock which might have interfered with the collected data. This made the collected data unreliable for analysis. (OF-A,B,6)

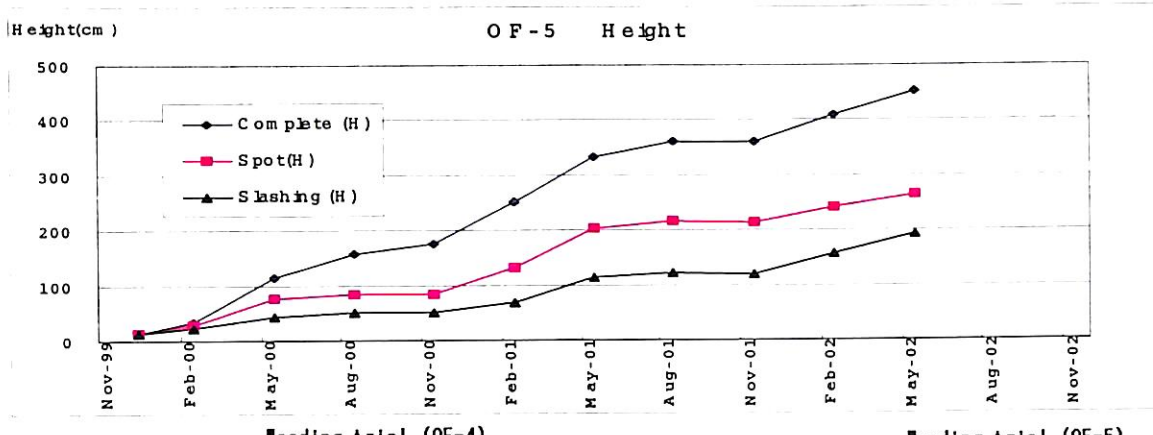
2 Some trial sites were intercropped and others were not. Farmers also intercropped with different

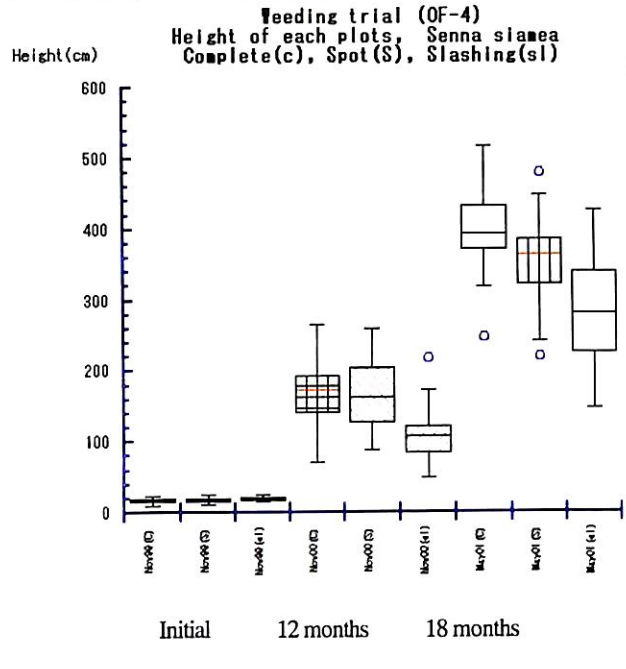
crops (maize, beans, cow peas and pigeon peas) and also the density of crops between the trees were made different for comparison. There was also difference in weeding, some farmers weeded their sites fully and on time while others weed late and partly.

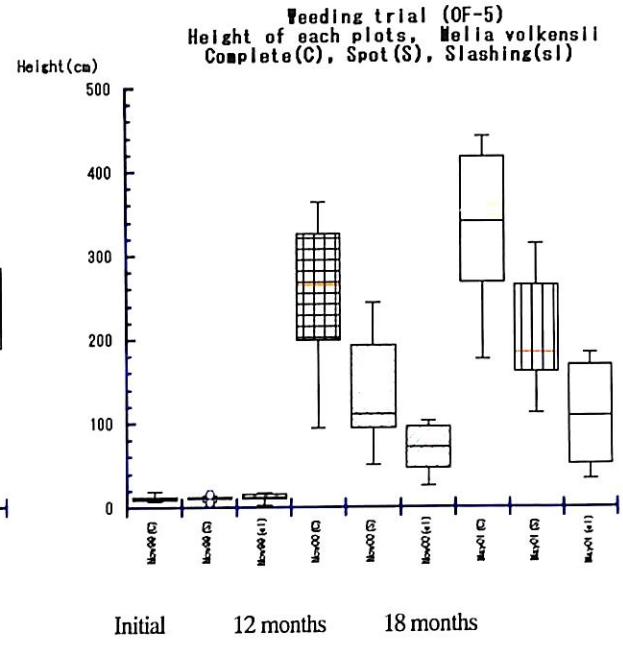
(3) After the analysis, the following were observed.

Weeding trial ---- The effect of different weeding techniques showed clearly a significant difference. This confirmed the importance of complete weeding during the initial years.



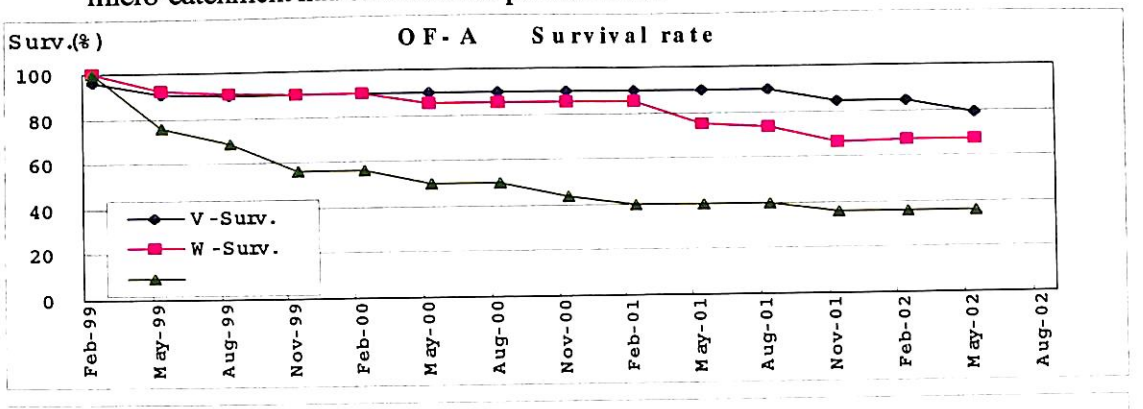


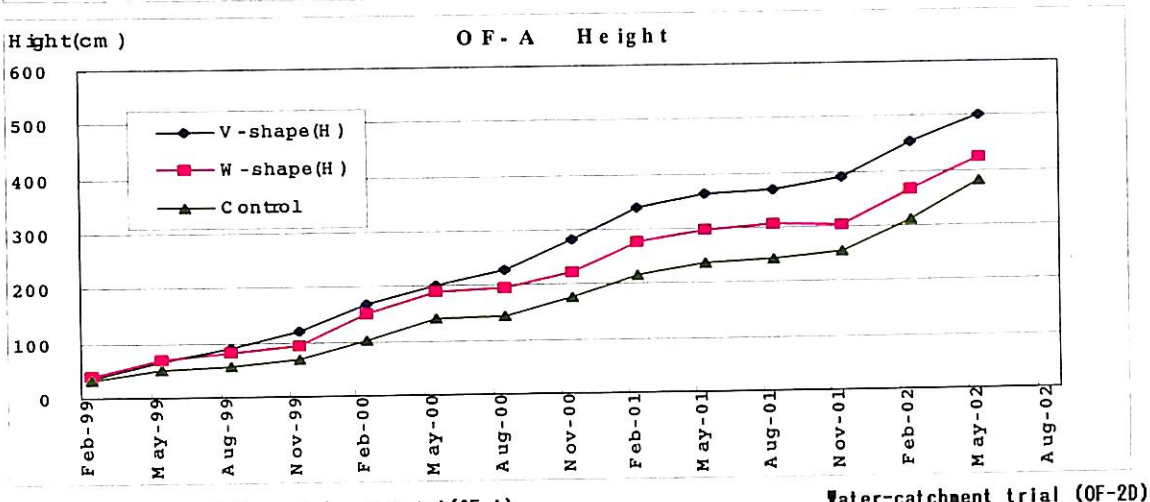


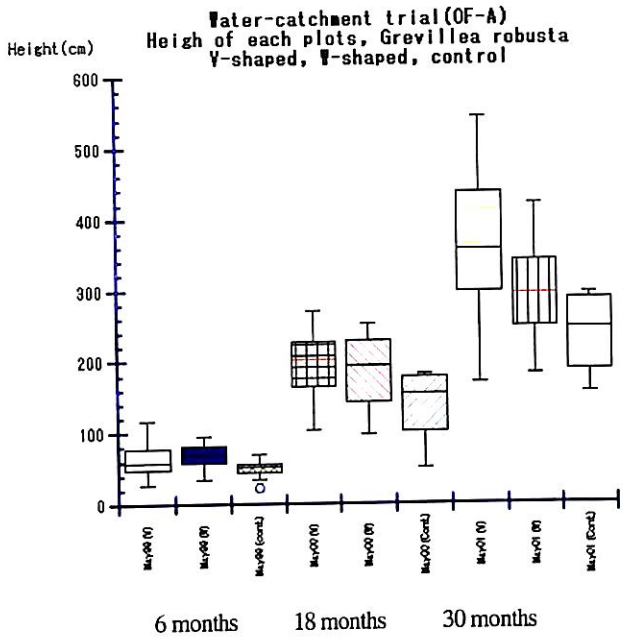


Water harvesting trial ---- Only one trial site a significant difference was observed. The area is

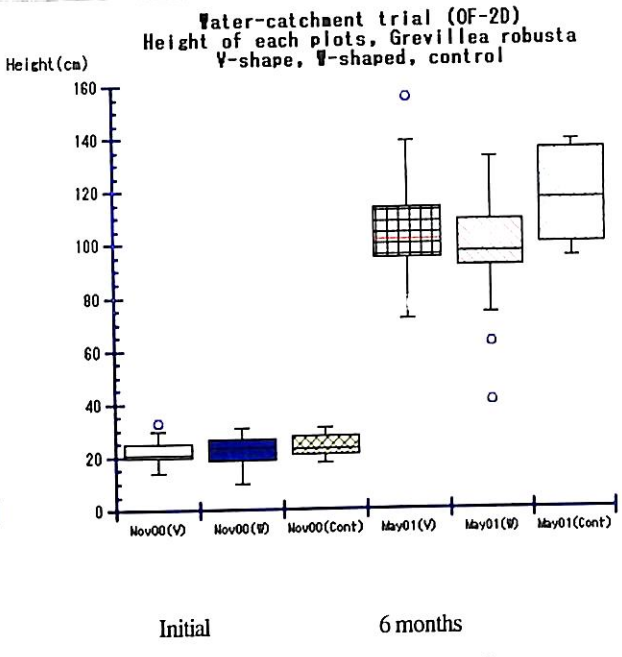
sloppy and therefore micro-catchment could collect a lot of run off. In this site, micro-catchment had effect on the planted trees.







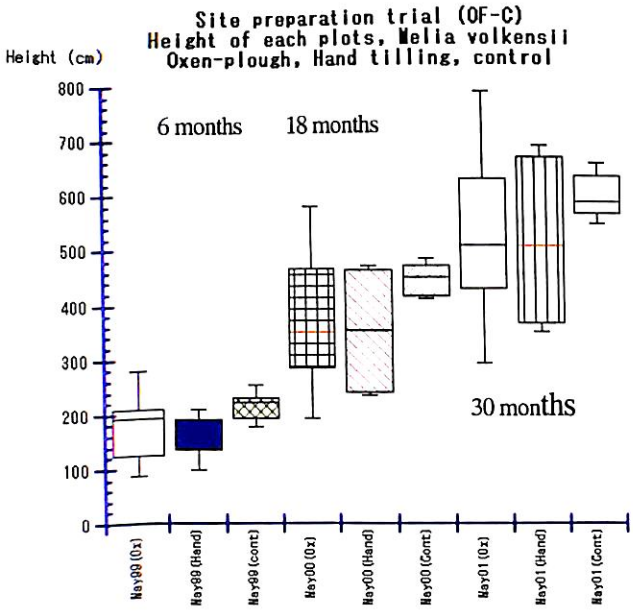
6 months 18 months 30 months

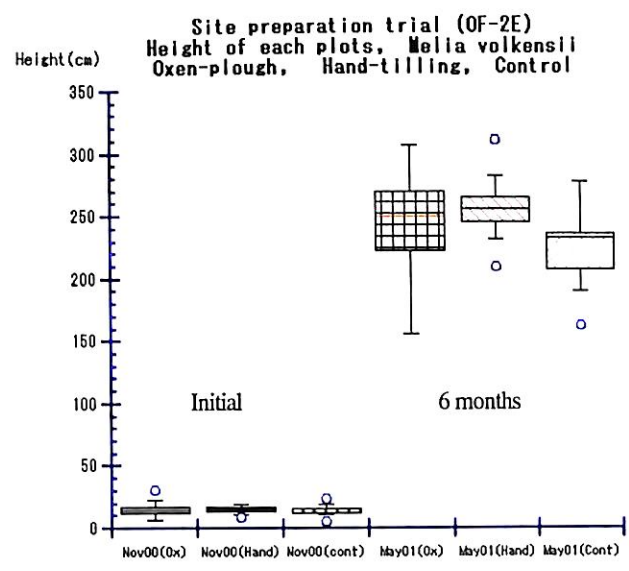


Initial 6 months

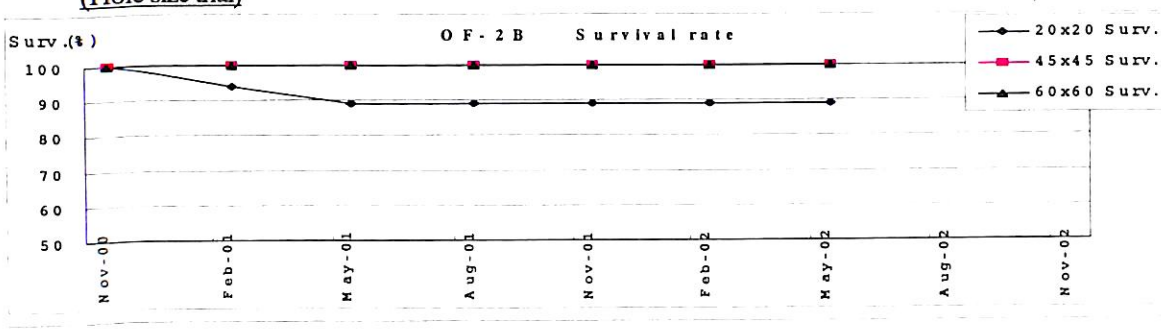
Site preparation and Hole size ---- Some sites showed a significant difference, but the reason was not because of the treatments but due to browsing and poor soils. Therefore the effects of hole size and site preparation could not be confirmed. The site preparations and hole sizes did not affect trees' survival rates and growth performance.

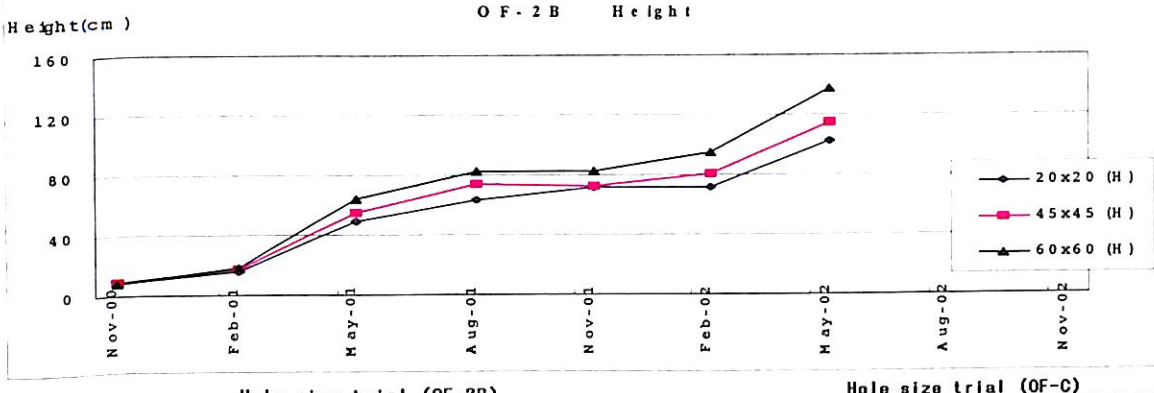
(Site preparation)

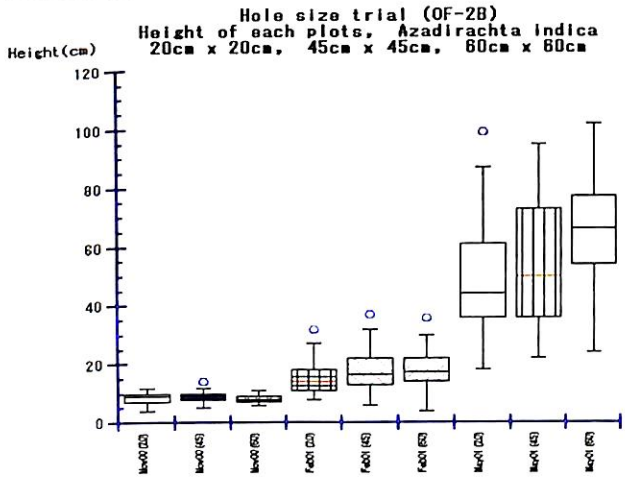


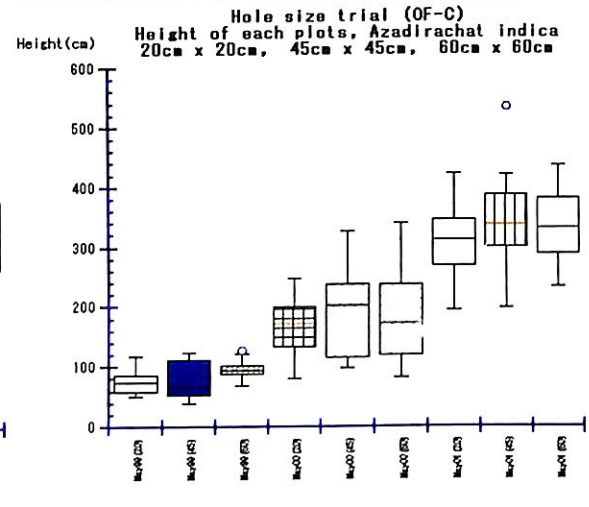


(Hole size trial)



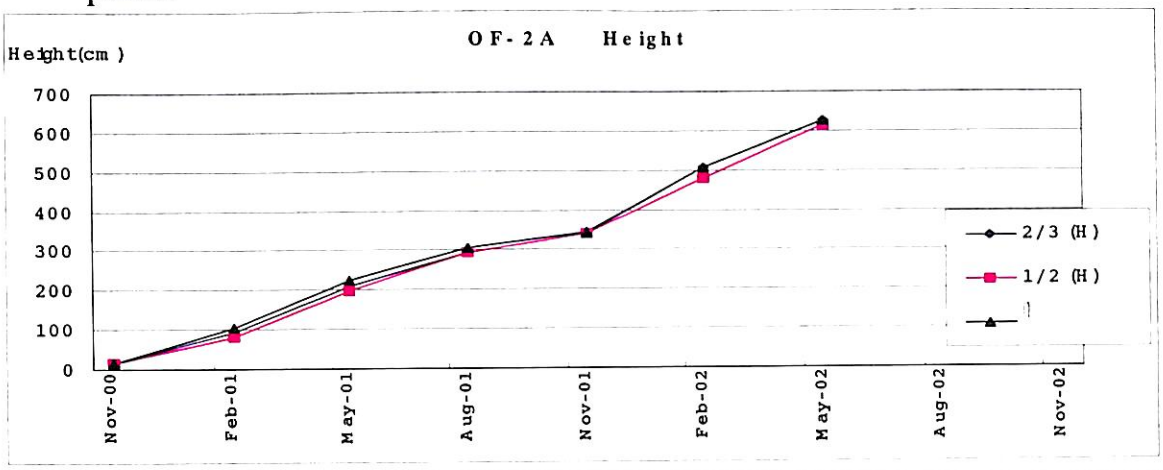


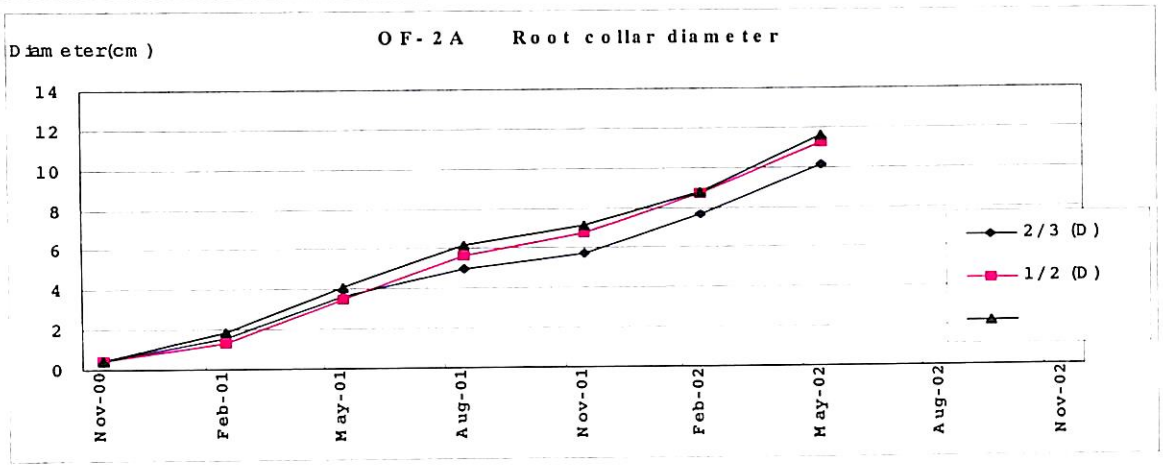




4 Pruning trial ---- First pruning was conducted in May 2001 and the generated data could not

be used for analysis to give a conclusive result. *Melia volkensii*, which was used for this trial produced many branches, which reduced the size of DBH and they were shading during the dry period.



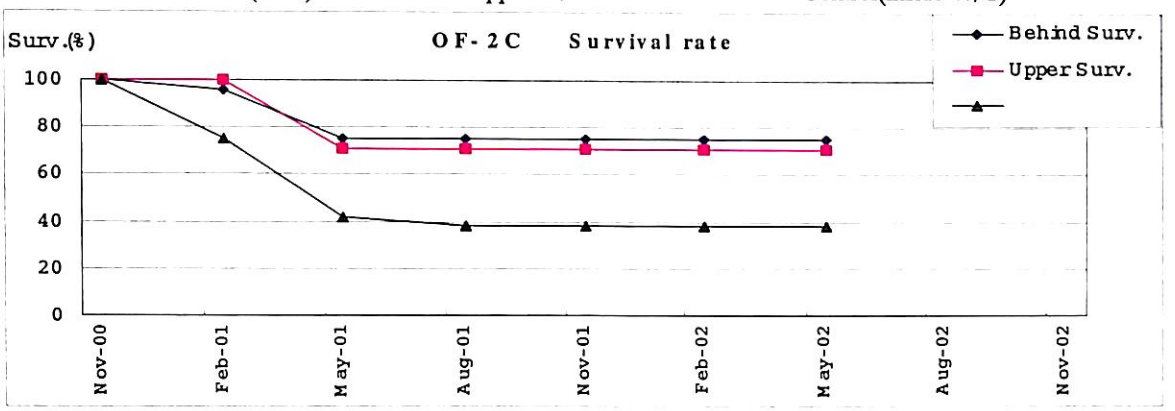


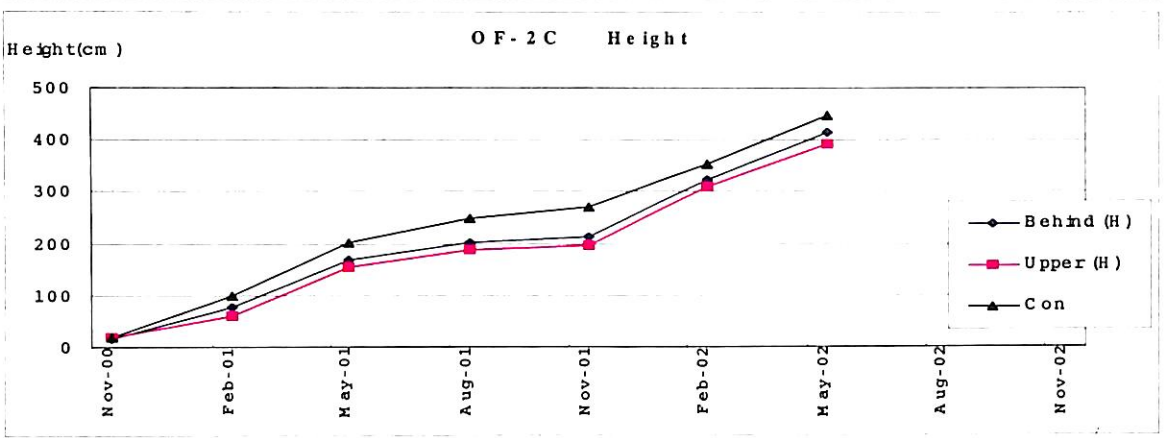
OF-2A Pruning plot (1/2 of height)

OF-2A Control plot (no pruning)

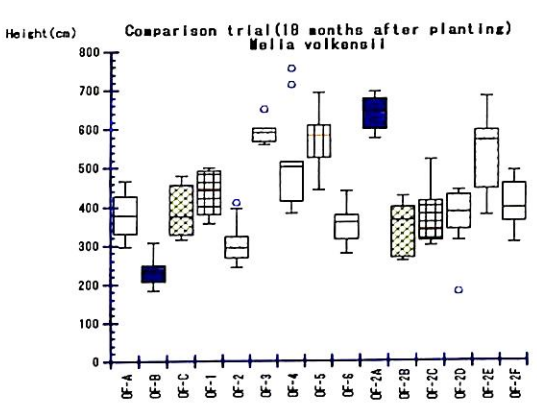
5 *Melia volkensii* planting site trial ---- Under this trial site, it was confirmed positive effect of avoiding the *Melia volkensii* from water logging. By avoiding water logging, survival rate of young planted *Melia volkensii* can be drastically improved.

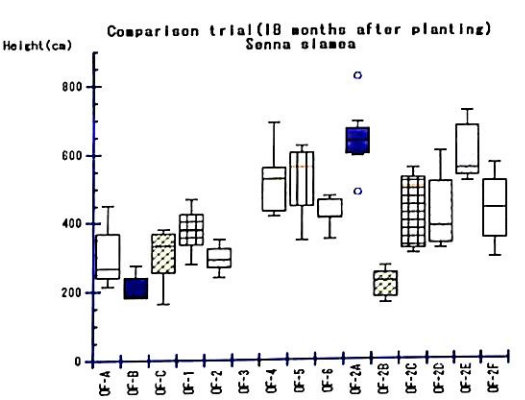
Behind Water-catchment(W/C) Upper W/C Control(inside W/C)





Growth rate comparison trial ---- The results showed that *Melia volkensii* was faster than *Senna siamea* after one year in terms of growth. Depending on rainfall amount, soil fertility the range of the growth of the trees is very wide. If intensive site management, such as complete weeding is conducted within one and half years both species can grow from 3m to 6m.

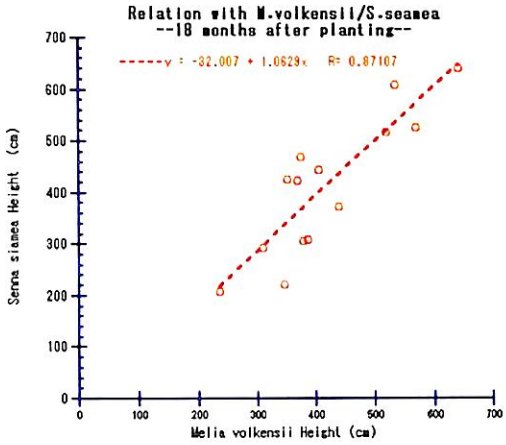




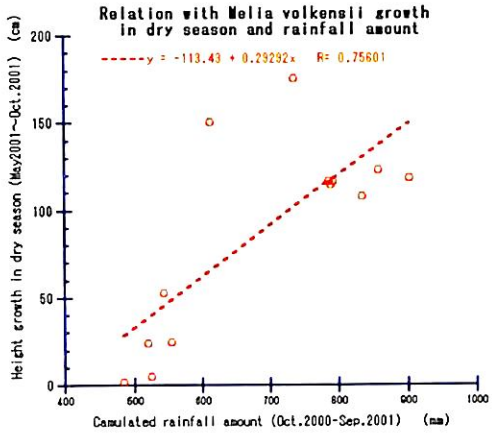
It was also confirmed that both species have high ability in drought tolerance, termite resistance and growth performance.

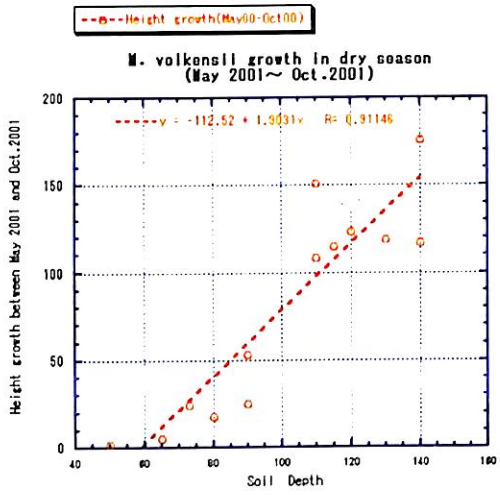
Through the collected data, strong interrelation between rainfall amount and growth performance was observed. And also, strong interrelation between growth during the dry period and soil depth/cumulated rainfall amounts were confirmed.

(High interrelation between Melia volkenii growth and Senna siamea growth)



(High interrelation between Melia volkenii growth in dry season and rainfall amount/soil depth)





(3)In addition, through monitoring, the following were also observed.

When the trial site is intercropped, the weeding is conducted fully and on time.

If crop is planted more than one meter away from the planted trees, competition for moisture is minimized.

(4) It is important for KEFRI to continue the data collection/monitoring of all 15 on-farm trial sites after the completion of the project.

Discussion

Through the on-farm trial, complete weeding and spot weeding showed strong effect on the growth performance of the planted trees. Under certain conditions, water harvesting showed some positive effects. Concerning the hole size and site preparation, there was no significant difference between the treatments. Therefore the technologies developed in the Pilot forest are more effective for farm forest establishment. Complete weeding (Spot weeding) and water harvesting technologies, can therefore be extended to the farmers.

However, when extending the farm forest establishments technologies to the farmers, the following factors should be considered: -

(1) Depending on site condition of the farmland, it is important that the technologies which farmer can undertake with minimum amount of labor should be extended under the range which is expected to give good survival and growth.

(2) The pilot forest is located in the most dry part of project operation area and where the rainfall amount is much higher than what is found at pilot forest, the recommended intensive technologies be modified.

(3) Many farmers practiced intercropping using maize, beans and cow peas in the two rain seasons and where farmers planted their crops more than one meter away from the trees hedge showed very minimal water stress (farmers who sowed 5 – 6 lines of maize between tree hedges or cow peas which covered all the trial site, trees showed slow growth.) and the intercropping trial which was conducted in the pilot forest showed almost same results (In the case up to 50% crop cover did not affect the trees growth).

Based on the on-farm trial results, farm forest establishment technologies can be modified/improved as follows;

1 Weeding

Complete weeding (Removal of all the weeds within the planted area) and spot weeding (weeding around the individual planted tree) should be recommended.

- Complete weeding ------- **In case of farmer intending to carry out intercropping.**

Crops should be planted more than one meter away from planted trees. Weeds near the trees should be removed two or three times in long rain and one or two times in short rains.

- Spot weeding ------- **In case of farmer not conducting intercropping.**

The spot weeded area should be between 1m – 1.5m radius from the tree (about two time of the tree height). The spot weeded area should be expanded depending on the trees growth. Weeding should be conducted two or three times in the long rains and one to two times in short rains.

2. **micro-catchment ------ Basically constructed where rainfall amount is limited** (where land is flat, or terraces have been constructed there is no need to construct micro-catchment. Where slope is more than 5% contour trench is recommended.

3. **Hole size**

Considering the pot size, 30cm×30cm hole can be used.

But if the planting site contain murram, the planting hole size can be increased.

4. **Site preparation**

Through ploughing or tilling, water infiltration can be enhanced in the soil.

In case farmer intercrops, the ploughing or tilling is automatically conducted and therefore extra operation is not recommended. Where intercropping is not carried out, ploughing/ tilling is not necessary because the effect is little and required labor is big.

5. **Pruning**

It is mostly recommended that the farmer plants trees for the purpose of getting timber.

Water catchments trial

1 Objectives

To apply and verify developed practical water-catchments' technologies for tree planting in ASALs using farmers' resources.

2Site descriptions

Five water catchments trial sites were established in 1998, 1999 and 2000 in four divisions, namely Kabati, Chuluni, Central and Mutomo, as shown in table 1 & 2.

Table1 (Farmer's name & location)

Trial Site	Farmer's name	Location	Year Established
OF-A	Mrs. Lucia Mutava	Kyangwithya West / Central Div.	1998
OF-B	Mrs. Monica Nguli	Matinyani / Kabati Div.	1998
OF-C	Mr. David Ngonde	Nzangathi / Chuluni Div.	1998
OF-6	Mr. Manundu Nyamai	Ikanga / Mutomo Div.	(1999) 2000
OF-2D	Mr. Boniface Mutia	Kisasi / Chuluni Div.	2000

Table2 (Site description)

Trial Site	Area(ha)	Eco-Zone	Slope (Terrace)	Soil	Rainfall (mm)	Pre-site condition
OF-A	0.09	-2	25° (none)	Luvisols PH 6.7-7.3 Effective depth 65cm Soil texture SCL	Oct.1998571 Oct.1999624 Oct.2000523	Grazing Land
OF-B	0.13	-2	5° (exist)	Regosols PH 8.4-8.8 Effective depth 50cm Soil texture SL	Oct.1998627 Oct.1999899 Oct.2000483	Farm land
OF-C	0.08	-2	4° (exist)	Cambisols PH 5.0-6.2 Effective depth 110cm Soil texture SL	Oct.1998572 Oct.1999766 Oct.2000831	Farm land
OF-6	0.16	-1	0° (none)	Luvisols PH 6.2-8.7 Effective depth 40cm Soil texture SCL	Oct.1999506 Oct.2000679	Farm land
OF-2D	0.14	-2	0° (exist)	Acrisols PH 5.8-7.0 Effective depth 80cm Soil texture SL	Oct.2000900	Farm land

3 Methods

(1) Experimental design

The experiments were set as complete randomized block design with three treatments (V-shape, W-shape, control(no catchments)) and two replicates. Survival rates and growth (heights and root color diameters) were assessed every three months, and monitoring was conducted every month to confirm the trial trees' growth performance.

(2) Planting and tending techniques

If the trial site was virgin, clearing of bushes and removal of all the existing vegetation was conducted. After that, planting and tending techniques were carried out.

1) Planting (including site preparation)

Site preparation ----- oxen-plough

Spacing was 3.5m x 3.5m

Hole size 45cm x 45cm

Water-harvesting structure ----- W-shape, V-shape, control(no catchments)

Trial species; Grevillea robusta(OF-A,B,C,2D), Azadirachta indica(OF-6)

2) Tending

The following tending techniques were conducted.

Repairing of broken micro-catchment.

Weeding ----- Complete weeding (Two times in each rain season.)

Basically, farmers were supposed to manage the trial site, but where there was need, the project workers assisted on the management of the site.

Results

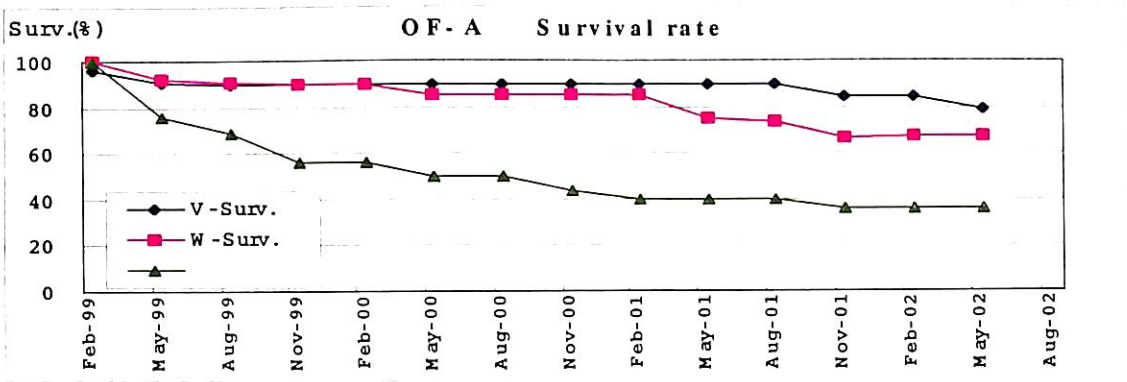
(1) Survival rate

The survival rate of the trees a year after planting in each trial site, showed that the control plot of on-farm A was below 60% while many others had over 90% and there was no significant difference between the treatments.

The reason was thought that, the trial sites apart from on-farm A were almost flat (sloppy areas had been constructed as terraces). So, run off water was reduced automatically. Sites except on-farm 6, the surface soils were sandy and thus infiltration was high reducing run off water.

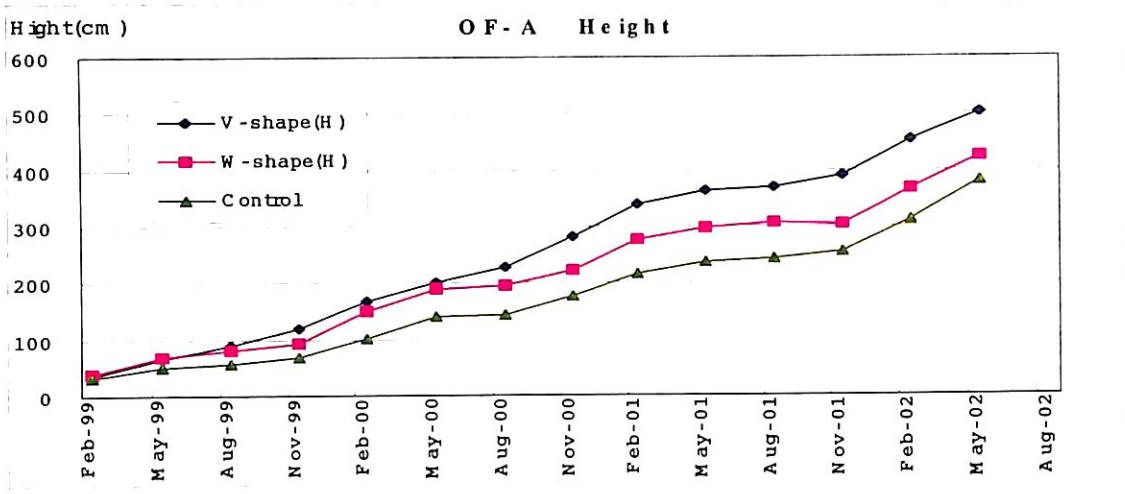
The effects of micro-catchments can only be realized when run off water is harvested. Considering the above conditions, the effect of micro-catchments could not be observed clearly.

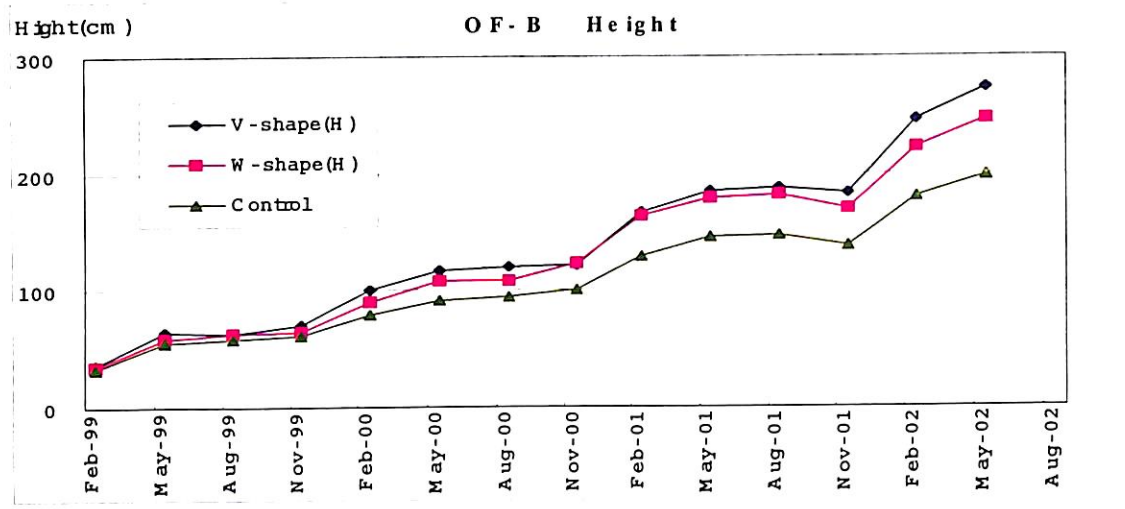
On the other hand, on-farm A the site was a bit sloppy (about 5%) and the area was cultivated for a long time. The top soil was washed away and whenever there was heavy rain, a lot of run-off was observed and so micro-catchments in this site could collect a lot of run off water which may have contributed to higher survival rate between 70% - 90%.

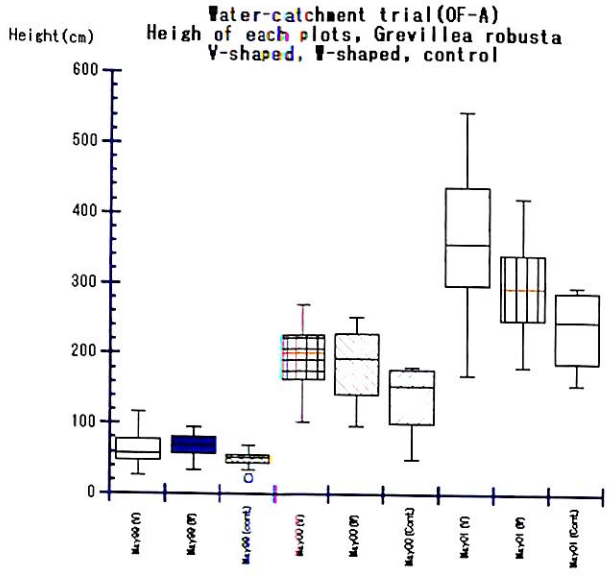


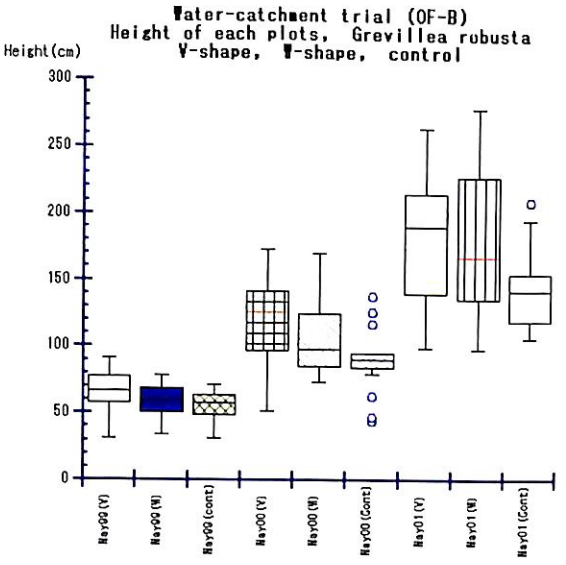
(2) Growth performance

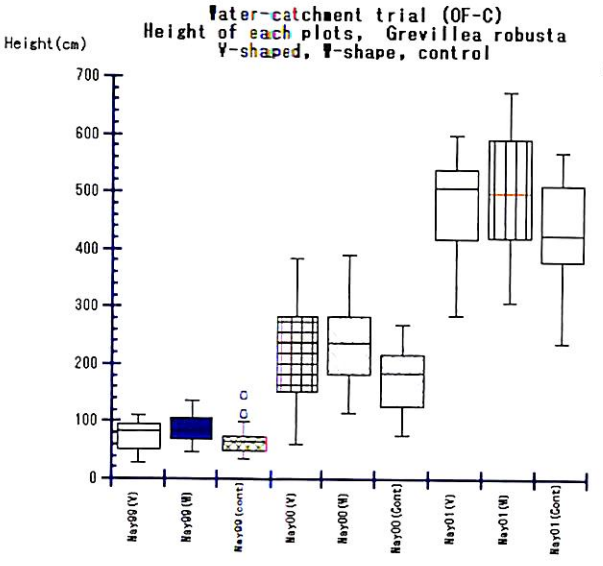
The growth (height and root collar diameter) of trees under V-shaped and W-shaped micro-catchments showed significant difference (P0.05)on-farm A and B. The other farms had no significant difference between different treatments. The reason may have been due to flat areas, which improved infiltration and so the effect of micro-catchments was not realized in growth.

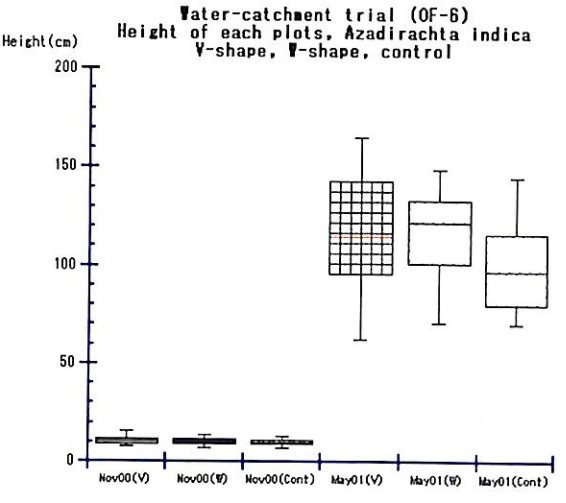




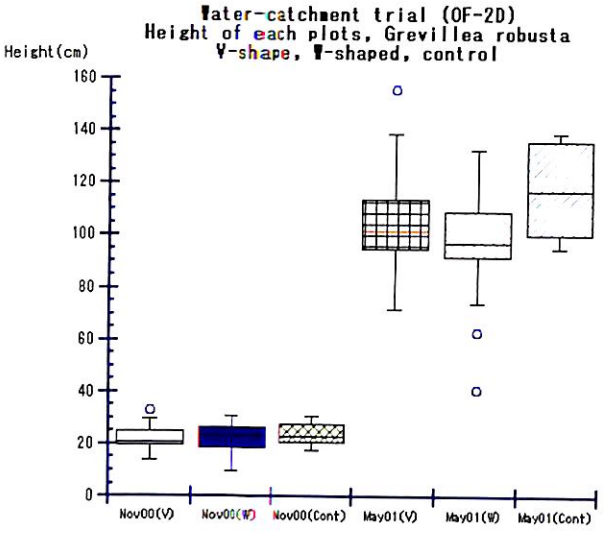








6 months 18 months 30 months Initial 6 months



Initial 6 months

Logically W-shaped is expected to collect more run off water than V-shaped, but in on-farm A, the growth of trees under V-shaped was higher than those under W-shaped catchments. The reason for this difference may have been contributed by the fact that, most of W-shaped catchments were more often broken by run off than V-shaped catchments.

Trees under micro-catchment plots in on-farm B performed better than control but this results may not have come from micro-catchments effect but because of varied soil fertility. The reason why it was thought so was that,

The site was terraced and therefore effect of micro-catchments was limited.

The soil type in this trial site was Calcaric Regosols. Layer A and B were very shallow. The lower sites of the slope were more shallow with low fertility levels (considering the yield of crop, and weeds in the plot, it was observed that the yield decreased down the slope).

The micro-catchment plots were located on the 1st and 2nd terrace but on the other hand the control plots were located 3rd and 4th terrace down the slope.

Where Regosols exist, it has been observed that soil fertility varies within a small area and such an area may not be suitable to conduct an experiment because the applied treatments may be influenced by the fertility factor rather than the treatments used.

Since we now understand this kind of problem, it will be important to avoid such a mistake in future.

Discussion

Through this experiment, the effect of micro-catchments was confirmed that where trees were planted on sloppy area with more run off. Where trials were set on flat area or terraced land, the micro-catchments effect was not clear. Logically, W-shaped micro-catchments can collect more run off than V-shaped micro-catchments, but if the embarked of W-shaped micro-catchments is weak (20cm high) the structure is easily washed way by the run off and therefore in such a case V-shaped is may be suitable because it is less broken by the run off considering the catchments area.

In addition, several trial sites, maize and beans were intercropped and where oxen plough was used micro-catchments were destroyed.

So, where oxen plough is used, this kind of damage can not be avoided. Therefore it is recommended to construct water harvesting structure which cannot be damaged by ploughing easily. This includes-

(1) Wide W-shaped micro-catchments

The angle of the constructed micro-catchments should be about 150°to 180°. This will reduce the damage of oxen-plough and pressure of collected water to one point. The collecting water point should be dug and reinforced with soil. The farmer should be advised to remove the soil from catchment basin wherever there is strong run off for maintenance purpose.

(2) Contour trench

Depending on slope of the land and soil type where micro-catchments cannot collect enough run off water because of the slope and soil type, a contour trench is recommended.

To construct a contour trench, more labor is required than when constructing micro-catchments, but the structure of contour trench is strong. The size and spacing of the contour trench from one to the other depend on the slope of the site and estimated run off water. From time to time, farmer should maintain those contour trenches by removing sift from the trenches.

Conclusion

From the results of the trials, it was confirmed that micro-catchments were more effective on the sloppy areas than on the flat sites and the terrace constructed sites.

Also, it was confirmed that weak micro-catchments structures (such as embankment height of 20cm high) were easily washed away by the run off and W-shaped micro-catchments were more easily broken than V-shaped by run off.

In addition, through monitoring it was confirmed that water harvesting structure which cannot be destroyed at the time of oxen ploughing need to be constructed because the standard micro-catchments structures cannot avoid getting damage when oxen ploughing is conducted. So, it was recommended that wide W-shaped micro-catchments and contour trench should be used. The verification of this idea need to be tested after the SOFEM project.

Micro catchments may not be necessary if the area to be planted is flat, terraced or intercropped. The use of micro-catchments is expensive because it requires frequent repairs and may not hold a lot of water especially on sloppy areas. But use of micro-catchments may be applicable on areas with gentle slopes, or if few trees are to be planted. Humid areas do not require micro-catchments.

Appendix – 1

Progress

Nov. 1998 Experiment plots were established in OF-A,B,C. *Grevillea robusta* was planted.

Nov. 1998Oct. 1999 All farmers except OF-C sowed maize/beans between the trees during the two rain seasons. Some trees were browsed by livestock in OF-A and B.

Nov. 1999 Experiment plot was established in OF-6. *Senna siamea* was used.

Nov. 1999Oct. 2000 All farmers except OF-C sowed maize/beans between the trees during the two rain seasons. Some trees were browsed by livestock in OF-A and B.

Jul. 2000 All planted trees in OF-6 died due to browsing by Dik-Dik and goats.

Nov. 2000 Experiment plot was established in OF-6 and 2D. *Azadirachta indica/ Grevillea robusta* were planted respectively.

Nov. 2000Oct. 2001 All farmers except OF-C sowed maize/beans between the trees in each rain season.

(Out line of care/ problem)

Trial Site	Weeding/ inter-cropping	Protection/ damage	Others
OF-A	Farmer inter-cropped maize/ beans/ cowpeas in each rain season. Complete weeding conducted by farmer/project worker.	Some trees got damage by oxen-plough. Some trees died due to continuous browsing by livestock.	Many micro catchments were broken by strong run offs. (Especially, W –shape)
OF-B	Farmer inter-cropped maize/ beans /cowpeas in each rain season. (Farmer could not get any harvest.)	Dik-Dik, goats and cows browsed some trees during the dry season.	
OF-C	No inter-cropping. Complete weeding properly conducted on time in each rain season by farmer.	There was no browsing problem.	
OF-6	Farmer inter-cropped maize/ beans in each rain season. Complete weeding conducted by farmer/project worker.	(All trees died due to browsing by Dik-Dik and goats in Jul. 2000.)	All *Senna siamea* trees were replaced with *Azadirachta indica* in Nov. 2000.
OF-2D	Farmer inter-cropped maize (2 lines) in each rain season in the first year. Complete weeding conducted by farmer/project worker.	There was no browsing problem.	

Site preparation trial

1 Objective

To verify the effective of different site preparation methods in ASALs in different areas and conditions (farm land) using farmers' resource.

2Site description

Four site preparation trial sites were established in 1998 and 2000, in four divisions namely Kabati, Chuluni, Central and Mutomo using *Melia volkensii* as shown below.

(Farmer's name & location)

Trial Site	Farmer's name	Location	Year Established
OF-A	Mrs. Lucia Mutava	Kyangwithya West / Central Div.	1998
OF-B	Mrs. Monica Nguli	Matinyani / Kabati Div.	1998
OF-C	Mr. David Ngonde	Nzangathi / Chuluni Div.	1998
OF-2E	Mr. Bartholomew Mutia	Ikanga / Mutomo Div.	2000

(Site description)

Trial Site	Area(ha)	Eco-Zone	Slope (Terrace)	Soil	Rainfall (mm)	Pre-site condition
OF-A	0.08	-2	25° (none)	Luvisols PH 6.7-7.3 Effective depth 65cm Soil texture SCL	Oct.1998571 Oct.1999624 Oct.2000523	Grazing land
OF-B	0.11	-2	5° (exist)	Regosols PH 8.4-8.8 Effective depth 50cm Soil texture SL	Oct.1998627 Oct.1999899 Oct.2000483	Farm land
OF-C	0.07	-2	4° (exist)	Cambisols PH 5.0-6.2 Effective depth 110cm Soil texture SL	Oct.1998572 Oct.1999766 Oct.2000831	Farm land
OF-2E	0.12	-1	0° (none)	Ferralsols PH 5.4-6.7 Effectivedepth 140cm Soil texture SCL	Oct.2000782	Grazing land

3 Trial Design

(1) Treatments

The experiments were set as complete randomized block design with three treatments (Oxen-ploughing, Hand-tilling, control(no plough/tilling)) and two replicates (Hand tilling/control plots of OF-A,B,C there were no replicates). Survival rate and growth (height and root color diameter) were assessed every three months and monitoring was conducted every month.

(2) Planting and tending techniques

If the trial site was virgin, clearing of bushes and removal of all the existing vegetation was conducted. After that, planting and tending techniques were carried out.

1) Planting (including site preparation)

Site preparation ----- oxen-plough, hand tilling, control (no plough/tilling)

Spacing was 3.5m x 3.5m

Hole size 45cm x 45cm

Water harvesting structure ----- W-shape micro-catchments(V-shape in 1998/1999)

Trial species; Melia volkensii

2) Tending

The following tending techniques were conducted.

Repairing of broken micro-catchment.

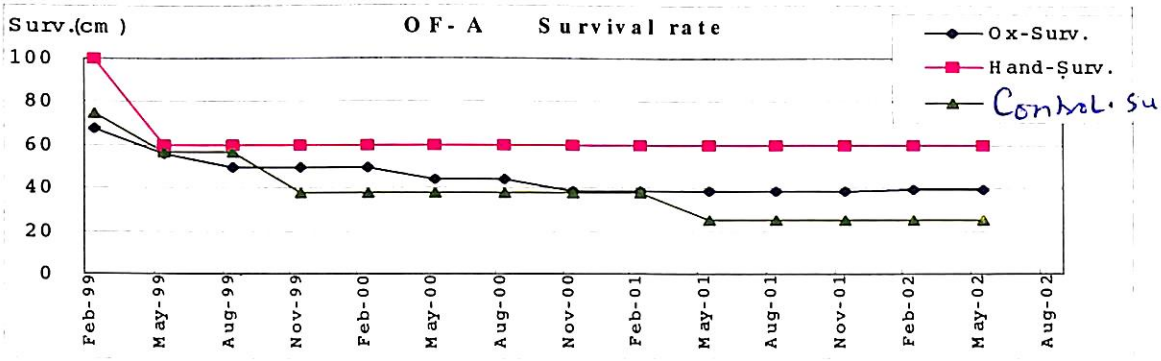
Complete weeding (Two times in each rain season.)

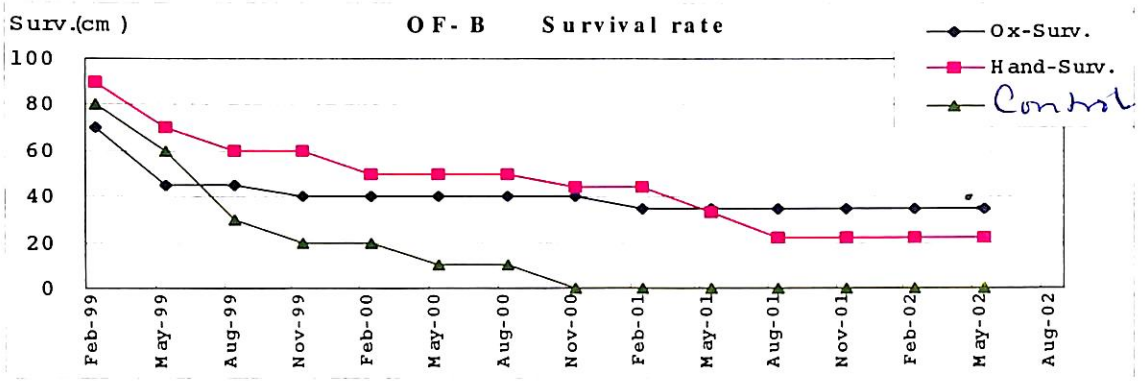
Basically, farmers were supposed to manage the trial plots, but where there was need, the project workers assisted on the management of the sites.

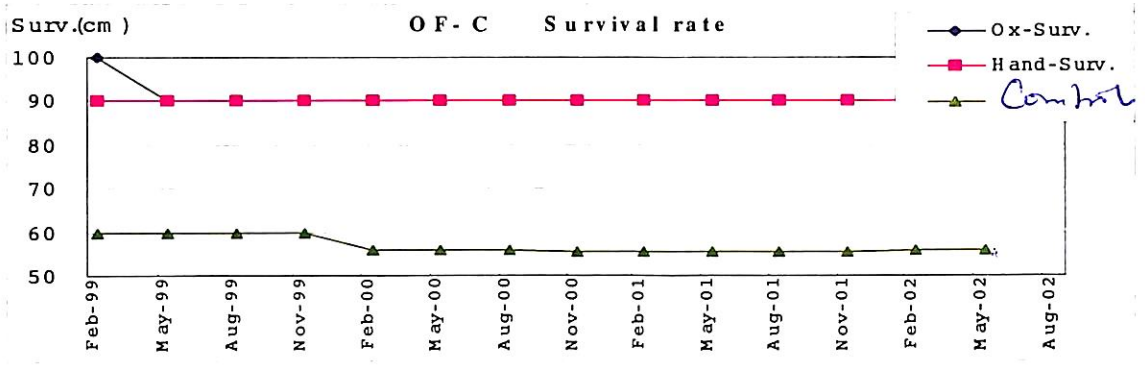
Results

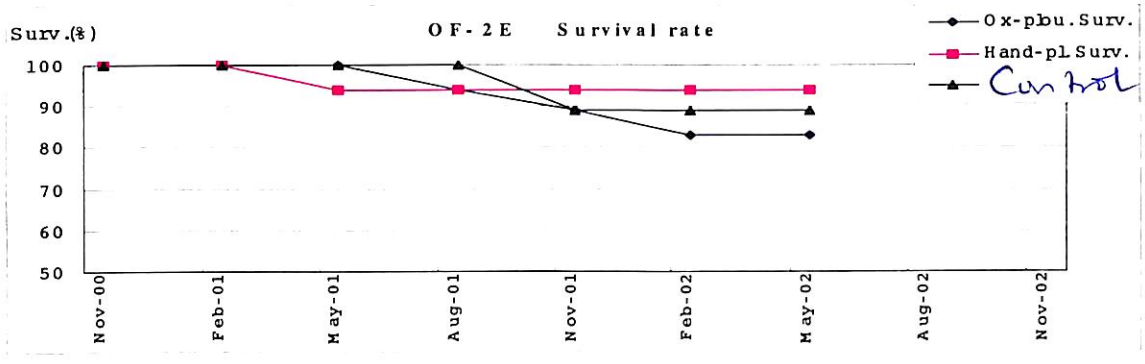
(1) Survival rate

The survival rate of trees one year after planting showed that, in on-farm (OF)-A rangewas 40%60%, OF-B was 20%60%, OF-C was 75%85% and OF-2E was90 %95%. The difference in survival rate between the both trial sites and treatments was big. The reasons of mortalities were different depending on the individual site. Sites where survival rates were low, the major reason was due to browsing by livestock and physical damage by oxen-ploughing. Because of physical damage and browsing which affected the survival rate of the trees, the effect of the different site preparation could not be ascertained. The all the trial sites, the number of trees which died due to drought could not be confirmed.









(2) Growth performance

Except oxen-plough plot in on-farm B significant difference was not observed. One year after planting when the effect of site preparation was expected to be observed, there was no significant differencebetween different treatments except oxen plough plot in on-farm B.

But there was significant difference between different sites.

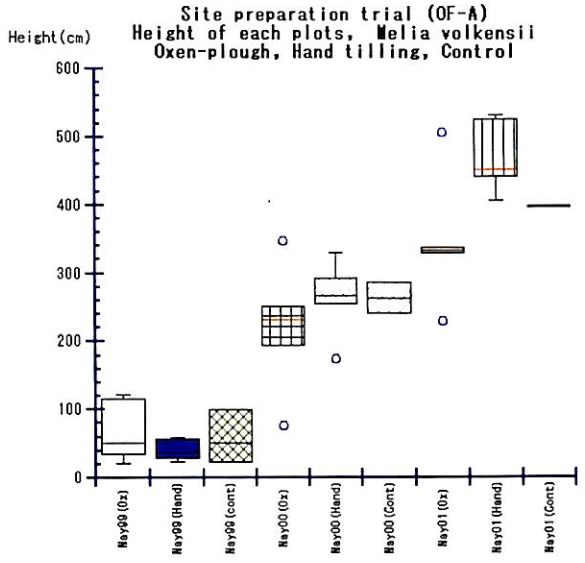
Trees under oxen-plough plots in on-farm B performed better than other plots although the reason

may not have come from oxen-plough effect but because of soil fertility and browsing problem. The reason why it was thought so was that,

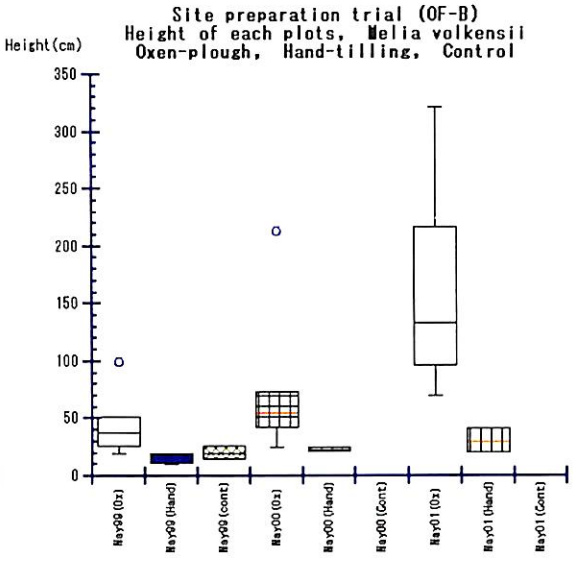
The soil type in this trial site was Calcaric Regosols. Layer A and B were very shallow. The lower sites of the slope were shallower than upper sites with low fertility levels (considering the yield of crop, and weeds in the plot, it was observed that the yield decreased down the slope).

The oxen-plough plots were located on the 3rd and 4th terrace, hand tilling plot was located 5th terrace and controls plot was located 6th terrace down the slope.

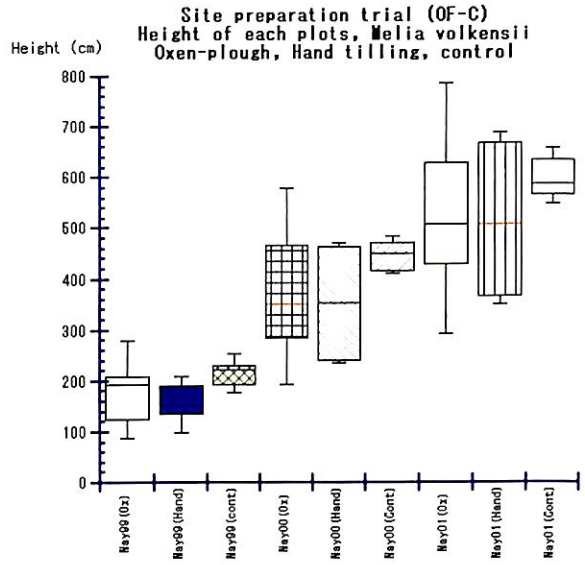
Browsing problem of this site was severe. It was observed that the slow growing trees had more browsed by livestock.



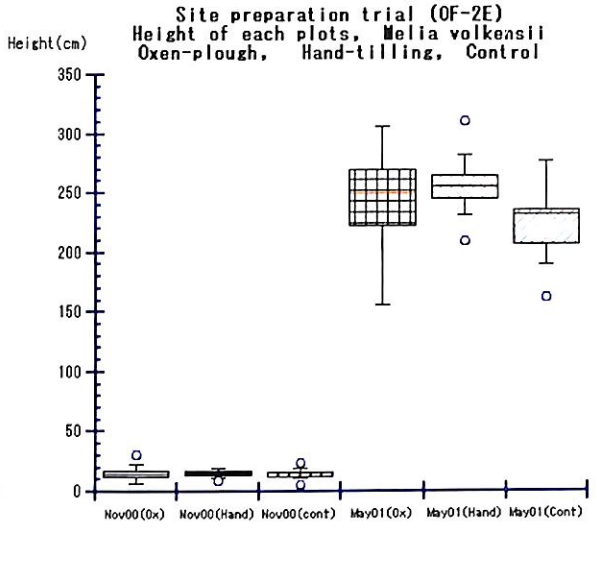
6 months 18 months 30 months



6 months 18 months 30 months



6 months 18 months 30 months



Initial 6 months

Discussion

From the on-farm results the effect of different site preparation method was not confirmed. It was also noted that the control plot performed almost the same with ploughing and tilling treatments. If mortalities caused by physical damage (ploughing) or browsing were not considered, the survival rate could be more than 90% in all the trial sites. Basing on the above observations, there were two notable things, i.e.

Through ploughing the roots of the weeds and bushes are removed leading to reduction of moisture competion.

By ploughing or weeding land surface crust is broken thus increasing infiltration of water and aeration into the soil.

The reason why the on-farm site preparation experiments did not show significant difference was that :

Most of the on-farm trial plots were located in already cultivated land, where bushes were already removed.

After the establishment of the site preparation trials, farmers weeded those sites several times, which reduced the effect of initial treatments (site preparation).

Based on the results from site preparation trial conducted in pilot forest in 1995, bulldozer ripping gave the best result followed by oxen ploughing, hand tilling and last control in that order.

The reasons why these results were observed may be:

During the site preparation in the pilot forest, and after the clearing the natural vegetation, a lot of roots remained under the ground, which competed with planted trees for moisture and nutrients.

Almost all the trial plots in pilot forest were established in a sloppy areas and soils contain a lot of clay which generates a lot of run off water. By preparing the land using bulldozer, deep area is cultivated removing a lot of roots of bushes and weeds. This leads to less competition between roots and planted trees. The loose soil also enhances water infiltration increasing moisture content into the soil.

Through the on-farm trial results, the effect of different site preparation techniques was small in a cultivated land. And also, if intensive site management practices are conducted (especially complete weeding) application of different site preparation techniques may not have any effects on planted trees.

So, it is suggested that if farmer intercrops, site preparation becomes one of agricultural practices and there is no need for extra site preparation. And if intercropping is not implemented, then ploughing or tilling is not necessary.

Conclusion

In the case of planting trees in the cultivated land, if intensive management is practiced (especially complete weeding) site preparation becomes unnecessary.

Where intercropping is conducted, site preparation becomes part of agricultural practice and therefore there is no need for extra operation.

If tree planting is undertaken on a virgin land, removal of all the existing roots must be removed fully. This will reduce any competition for moisture and nutrients.

Appendix – 1

Progress

Nov. 1998 Experiment plots were established in OF-A,B,C. Melia volkensii was planted.
Nov. 1998Oct. 2000 All farmers except OF-C sowed maize/beans between the trees in the two rain seasons. Many Melia volkensii died because of water logging/browsing in OF-A and B.

Nov. 2000 Experiment plot was established in OF-2E. Melia volkensii was planted.
Nov. 2000Oct. 2001 All farmers except OF-C sowed maize/beans between the trees in each rain season.
Harvested amount of crops were OF-2E>OF-A>OF-B

(Out line of care/ problem)

Trial Site	Weeding/ inter-cropping	Protection/ damage	Others
OF-A	Farmer inter-cropped maize/ beans/ cowpeas in each rain season.	Some trees got damage by oxen-plough. Some trees died due to continuous browsing by livestock.	Many water-catchments were broken by strong run offs. (Especially, W-shape)
OF-B	Farmer inter-cropped maize/ beans /cowpeas in each rain season. (Farmer could not get any harvest.)	Dik-Dik, goats and cows browsed some trees during the dry season.	
OF-C	No inter-cropping. Complete weeding conducted on time in each rain season.	There was no browsing problem.	
OF-2E	Farmer inter-cropped maize (2 lines) in each rain season. Farmer conducted complete weeding on time. (Farmer harvested a lot of maize.)	There was no browsing problem.	Some M. volkensii trees were affected by fungus at the root color.

Appendix – 2

The main reason for trees mortalities within the individual sites

OF-A ----- After planting, some trees died due to water logging. Every time of intercropping, some trees were also damaged by oxen plough. During the dry period, many trees were browsed by livestock. It was observed that young planted trees died after continuous browsing by livestock and damage by oxen-plough. Following the above problems (browsing, damage by plough) after three years, the survival rate decreased from 60% to 20%.

OF-B ----- The reason for trees' mortalities in this trial plot was similar to that of on-farm A but the soil fertility was very low and the growth performance of trees was also low. So, almost all planted trees were browsed by livestock and getting damage by oxen-plough continuously for a long period. Following the above problems after three years, survival rate decreased from 35% to 0%.

OF-C ----- On this trial site, the problem of water logging was not witnessed as the soil was sandy and drainage was good. First one year after trees establishment, some planted trees were damaged by oxen-plough. After that, trees mortalities decreased drastically and three years after planting, the survival rate ranges from 55% to 90%.

OF-2E ----- Soil in the trial site contained a lot of clay but the trees were planted below the micro-catchment which keeps the trees away from water logging. During the dry period, some trees died due to a fungal disease (root rotted) but one year after planting the trial plots showed a good survival rate of 90% to 95%.

Hole size trial

1 Objective

To verify the effect of different planting hole' sizes for trees planted in ASALs in different areas and condition (farm land) using farmers' resource.

2Site description

Considering the rainfall amount, soil type etc., four sites were established in 1998 and 2000 in three divisions, namely Kabati, Chuluni and Central, using *Azadirachta indica* as shown below.

(Farmer's name & location)

Trial Site	Farmer's name	Location	Year Established
OF-A	Mrs. Lucia Mutava	Kyangwithya West / Central Div.	1998
OF-B	Mrs. Monica Nguli	Matinyani / Kabati Div.	1998
OF-C	Mr. David Ngonde	Nzangathi / Chuluni Div.	1998
OF-2B	Mrs. Florence Mwinzi	Katutu / Kabati Div.	2000

(Site description)

Trial Site	Area(ha)	Eco-Zone	Slop (Terrace)	Soil	Rainfall (mm)	Pre-site condition
OF-A	0.09	-2	25° (none)	Luvisols PH 6.7-7.3 Effective depth 65cm Soil texture SCL	Oct.1998571 Oct.1999624 Oct.2000523	Grazing land
OF-B	0.13	-2	5° (exist)	Regosols PH 8.4-8.8 Effective depth 50cm Soil texture SL	Oct.1998627 Oct.1999899 Oct.2000483	Farm land
OF-C	0.08	-2	4° (exist)	Cambisols PH 5.0-6.2 Effective depth 110cm Soil texture SL	Oct.1998572 Oct.1999766 Oct.2000831	Farm land
OF-2B	0.15	-1	0° (exist)	Vertisols PH 7.0-7.4 Effective depth 90cm Soil texture SL	Oct.2000542	Farm land

3 Method

(1) Treatment

The experiments were set as complete randomized block design with three treatments (20cm x 20cm,

45cm x 45cm, 60cm x 60cm) and two replicates. Survival rate and growth (height and root color diameter) were assessed every three months and monitoring conducted every month.

(2) Planting and tending techniques

In case where the trial site was virgin, clearing of bushes and removal of all the existing vegetation was conducted. After that, planting and tending techniques were carried out.

1) Planting (including site preparation)

Site preparation ----- oxen-plough

Spacing was 3.5m x 3.5m

Hole size 45cm x 45cm

Water harvesting structure ----- W-shape micro-catchments(V-shape in 1998/1999)

Trial species; Azadirachta indica

2) Tending

The following tending techniques was conducted.

Repair of micro-catchment ----- The broken micro-catchment were repaired.

Weeding ----- Complete weeding Two times in each rain season.

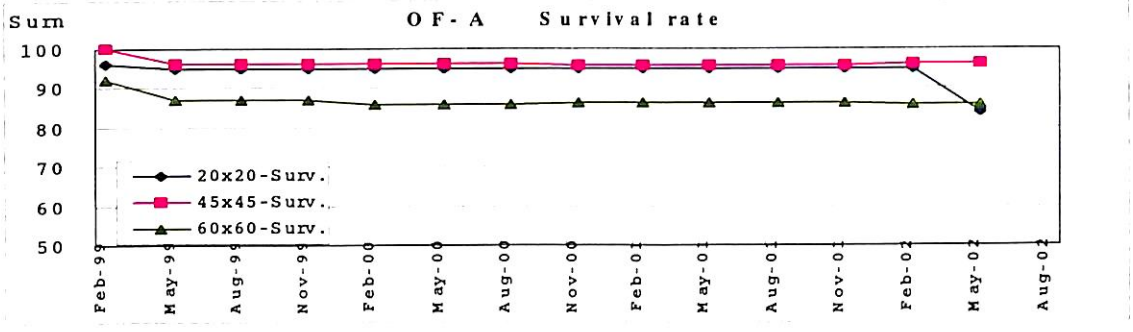
Basically, farmers were supposed to manage the trial site, but where there was need, the project workers assisted on the management of the site.

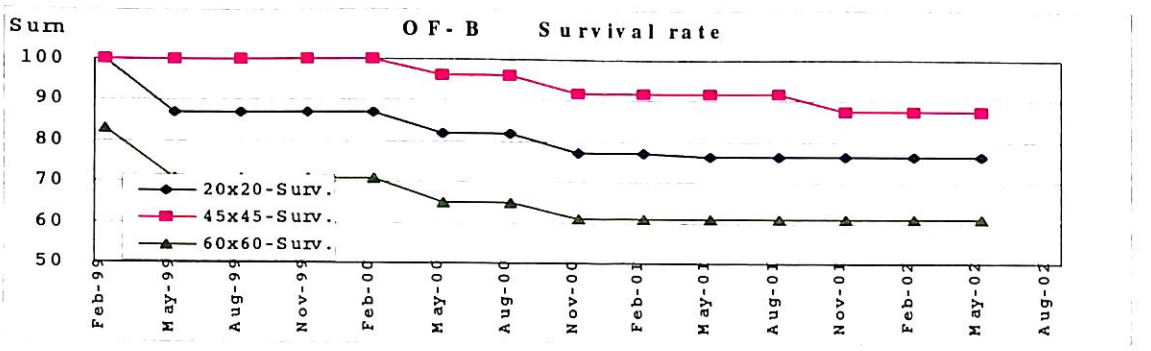
Results

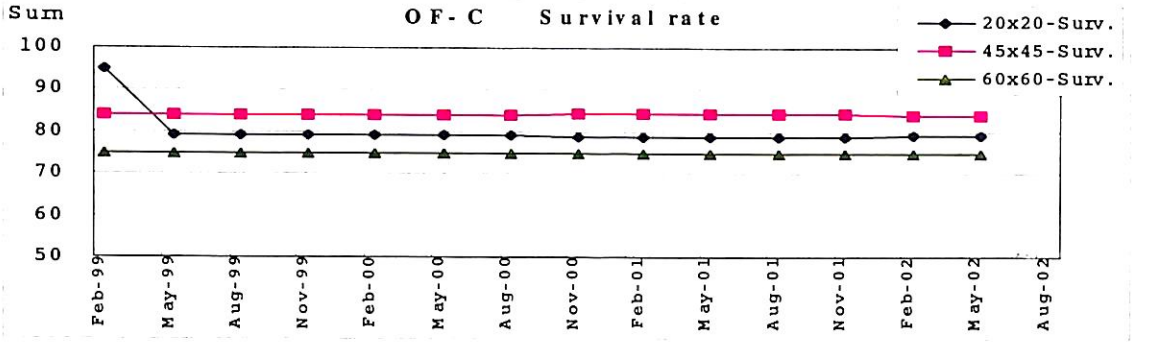
(1) Survival rate

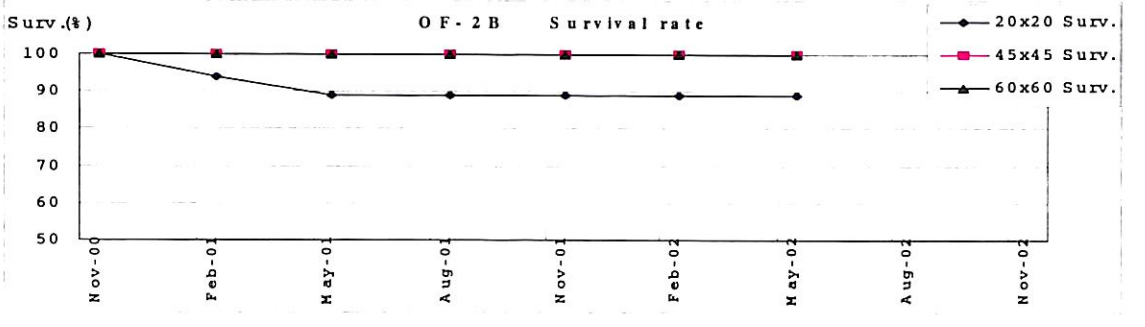
The survival rate of trees in 60cm x 60cm hole size plots in on-farm B was about 60%. But the survival rates in other trial sites ranged from 80% to 95%. The main reason for mortalities in 60cm x 60cm plot in on-farm B was due to browsing by livestock.

In other trials almost all trees mortalities were recorded at 6 months after planting and major reasons were due to physical damage by oxen-plough and browsing. If trees were well protected from browsers and physical damage may be the survival rate could have been over 90%.









(2) Growth performance

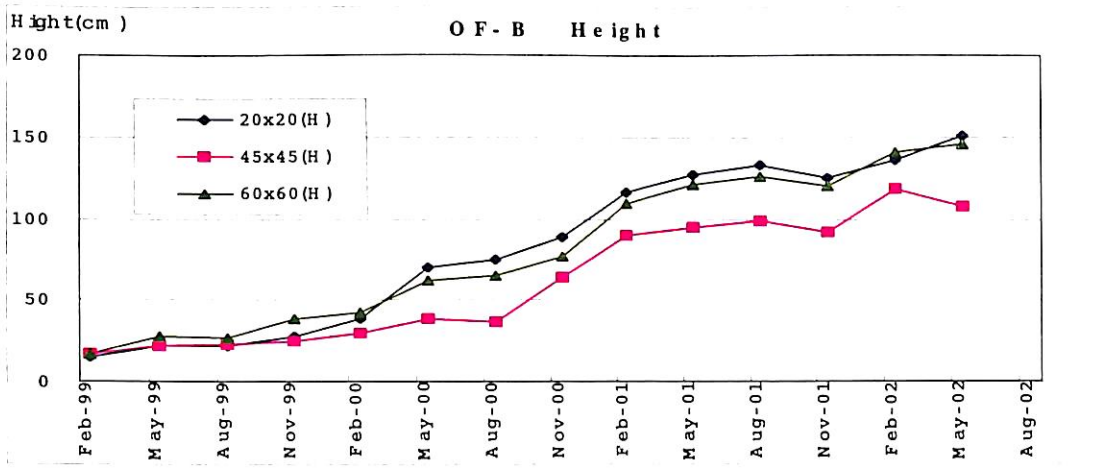
Apart from trees in 45cm x 45cm hole size plot in on-farm B, there was no notable significant difference between different hole sizes on growth performance.

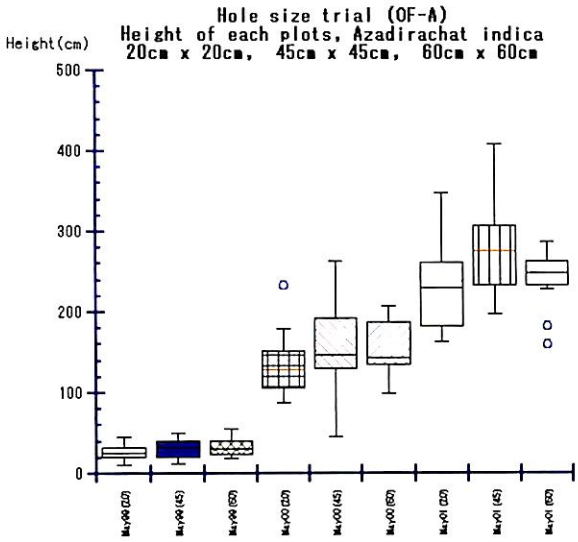
But trees under 45cm x 45cm hole size plots in on-farm B performed worse than other plots and the reason may not have come from hole size effect but because of soil fertility and browsing problem. The reason why it was thought so was that,

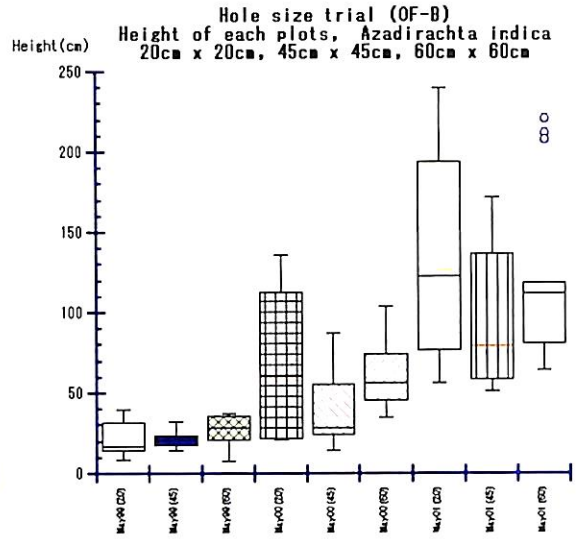
The soil type in this trial site was Calcaric Regosols. Layer A and B were very shallow. The lower sites of the slope were shallower with low fertility levels (considering the yield of crop, and weeds in the plot, it was observed that the yield decreased down the slope).

All 60cm x 60cm hole size plots and one 20cm x 20cm hole size plot were located on the 1st and 2nd terrace. On the other hand, 45cm x 45cm hole size plots were located on the 1st to 4th terrace and the portion of located terrace down the slope was high.

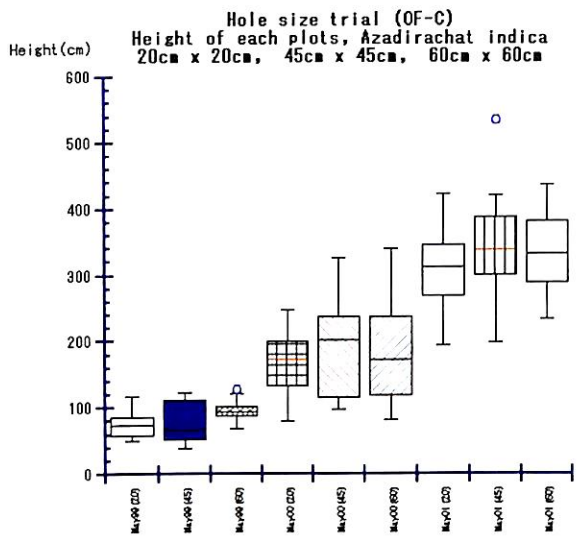
Browsing problem of this site was severe. It was observed that the slow growth of trees was caused by livestock browse.

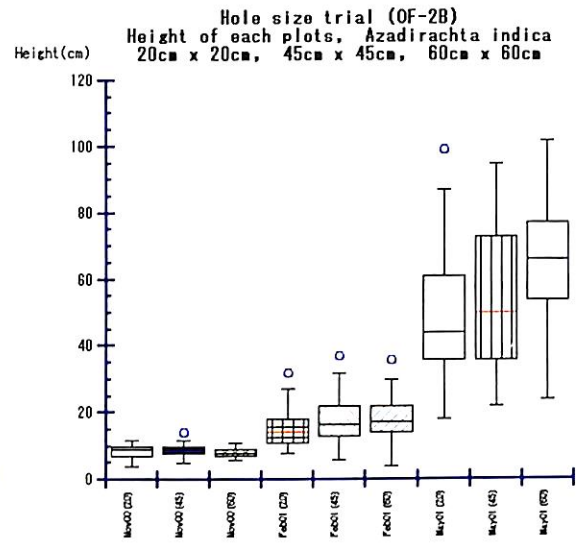






6 months 18 months 30 months 6 months 18 months 30 months





6 months 18 months 30 months Initial 3 months 6 months

Discussion

Through the on-farm trial results, it was confirmed that there was no significant difference between different hole sizes on trees survival and growth. The most remarkable point was that, trees under 20cm x 20cm hole size plot performed the same with other bigger hole sizes in terms of survival and growth. Considering the labor involved in making different hole sizes (volume of 60cm x 60cm hole is 27 times bigger than 20cm x20cm hole), this observation is very important.

Based on the results got from hole size trial in pilot forest in 1994, at 2 years, 60cm x 60cm plot gave the best results, followed by 45cm x 45cm and last 30cm x 30cm. The suggested reasons were that the planted plots were only bush cleared without removing the underground roots. There were no water harvesting structures and no intensive weeding (complete weeding).

Big hole can collect much run off water than small hole.

During the preparation of big hole, deep roots are also removed.

Soil scoped from the big hole, which can suppress nearby weeds and thus reducing moisture competition.

Because of the three above mentioned reasons trees planted in big holes could benefit from moisture contained in it during the initial stages.

Through on-farm trials, it was confirmed that if intensive site management is conducted (especially complete weeding) on the cultivated land, the effect of different hole sizes is small.

Where the trial plots were set, the shallow soil condition was not observed (hard pan/murram). Generally, by breaking the hard pan of the soil, one can improve the growth of planted tree's root. It is therefore, in such a site, big hole may be more effective than small hole. So, verification of this technology under shallow soil condition is required in future.

Conclusion

Through on-farm trial, it was observed that, if intensive site management practices are conducted (especially complete weeding) on the cultivated land, different hole sizes does not affect planted trees on survival and growth. Therefore, it may not be necessary to use big holes.

Appendix – 1

Progress

Nov. 1998 Experiment plots were established in OF-A,B,C. Azadirachta indica was planted.

Nov. 1998Oct. 2000 All farmers except OF-C sowed maize/beans between the trees during the two rain seasons. Some trees were browsed by livestock in OF-A and B.

Nov. 2000 Experiment plot was established in OF-2B. Azadirachta indica was planted.

Nov. 2000Oct. 2001 All farmers except OF-C sowed maize/beans between the trees in each rain season.

Harvested amount of crops were OF-A>OF-2B>OF-B

Sep. 2001 All trees were severely browsed by goats in OF-2B.

(Out line of care/ problem)

Trial Site	Weeding/ inter-cropping	Protection/ damage	Others
OF-A	Farmer inter-cropped maize/ beans/ cowpeas in each rain season. Complete weeding conducted by farmer/project worker.	Some trees got damage by oxen-plough. Some trees died due to continuous browsing by livestock.	Many water-catchments were broken by strong run offs. (Especially, W-shape)
OF-B	Farmer inter-cropped maize/ beans /cowpeas in each rain season. (Farmer could not get any harvest.)	Dik-Dik, goats and cows browsed some trees during the dry season.	
OF-C	No inter-cropping. Complete weeding conducted on time in each rain season by farmer.	There was no browsing problem.	
OF-2B	Farmer inter-cropped maize/ beans in each rain season. Complete weeding conducted by farmer/project worker.	Almost all trees were severely browsed by goat in Sep. 2001.	

Weeding trial

1 Objective

To apply and verify developed practical weeding methods for trees planted in ASALs in different areas and condition (farm land) using farmers' resource.

2Site description

Three trial sites were established in 1999 and 2000 in two division, namely Chuluni and Mutomo, as shown below.

(Farmer's name & location)

Trial Site	Farmer's name	Location	Year Established
OF-4	Mrs. Christine Kitema	Mbitini / Chuluni Div.	1999
OF-5	Mr. Gabriel Ndetei	Ikanga / Mutomo Div.	1999
OF-2F	Mr. Stephen Mulatya	Ikanga / Mutomo Div.	2000

(Site description)

Trial Site	Area(ha)	Eco-Zone	Slop (Terrace)	Soil	Rainfall (mm)	Pre-site condition
OF-4	0.16	-2	1° (none)	Luvisols PH 6.2-7.2 Effective depth 62cm Soil texture SL	Oct.1999636 Oct.2000(784)	Grazing land/ Farm land
OF-5	0.15	-1	0° (none)	Luvisols PH 5.6-7.4 Effective depth 80cm Soil texture SL	Oct.1999546 Oct.2000799	Grazing land
OF-2F	0.13	-1	0° (none)	Luvisols PH 6.7-8.1 Effective depth 90cm Soil texture SL	Oct.2000553	Farm land

3 Method

(1) Experimental design

The experiments were set as complete randomized block design with three treatments (Complete weeding, Spot weeding and Slashing) and two replicates. Survival rate and growth (height and root color diameter) were assessed every three months and monitoring was conducted every month to confirm the trial trees growth performance.

(2) Planting and tending techniques

In the case where the trial site was virgin, clearing of bushes and removal of all the existing vegetation was conducted. After that, planting and tending techniques were carried out.

1) Planting (including site preparation)

Site preparation ----- oxen-plough

Spacing was 3.5m x 3.5m

Hole size 45cm x 45cm

Water harvesting structure ----- W-shape micro-catchments (V-shape in 1998/1999)

Trial species; *Azadirachta indica* (OF-5, 2F), *Senna siamea* (OF-4)

2) Tending

The following tending techniques were conducted.

Repairing of broken micro-catchment.

Complete weeding (removal of all the weeds the planted area),

Spot weeding (weeding around the individual planted tree) and

Slashing ( )

-------- (Two times in each rain season.)

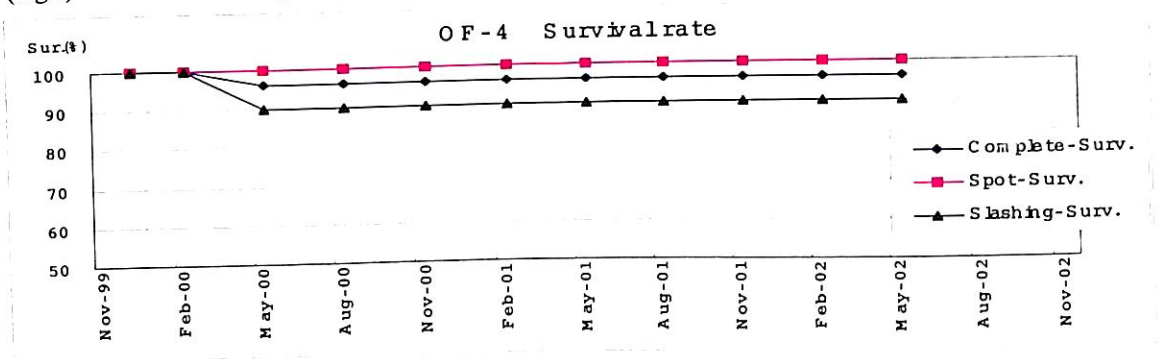
Basically, farmers were supposed to manage the trial site, but where there was need, the project workers assisted on the management of the site.

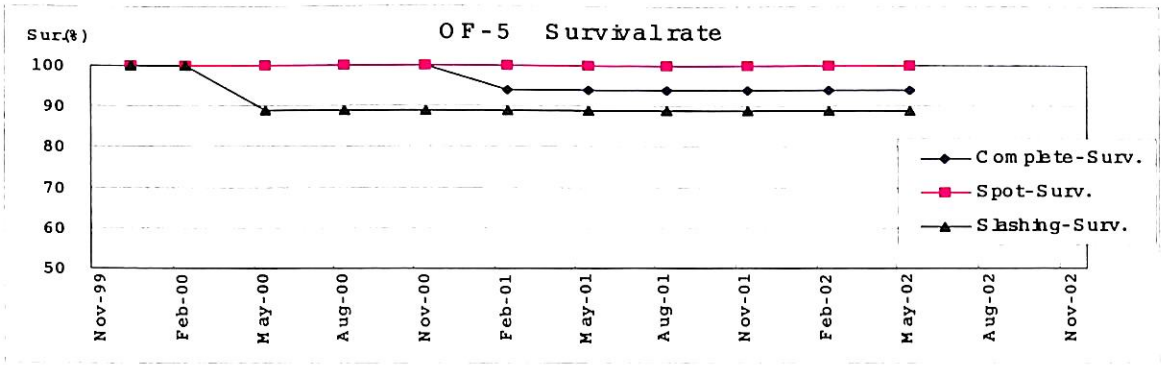
Results

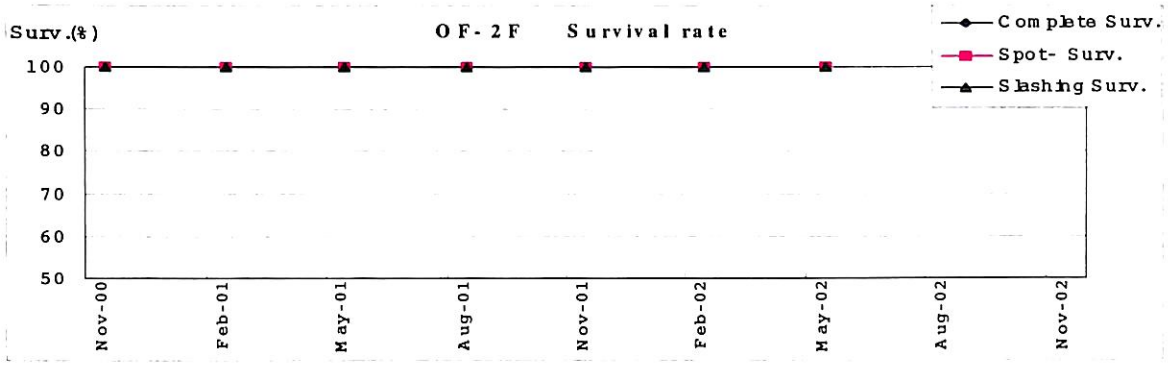
(1) Survival rate

One year after planting, the survival rate of the planted trees ranged between 88% and 100%, and there was no notable significant difference between different treatments. The survival rate never changed even two years later (see Fig.1). The several trees, which died, occurred between 4 to 6 months after planting. The mortality period was between end of short rain season and beginning of dry period. Major cause of the mortalities was due to browsing, and physical damage when slashing. The number of dead trees under weeding trials because of drought was not established.

(Fig.1) Survival rate of trees planted in weeding trials.







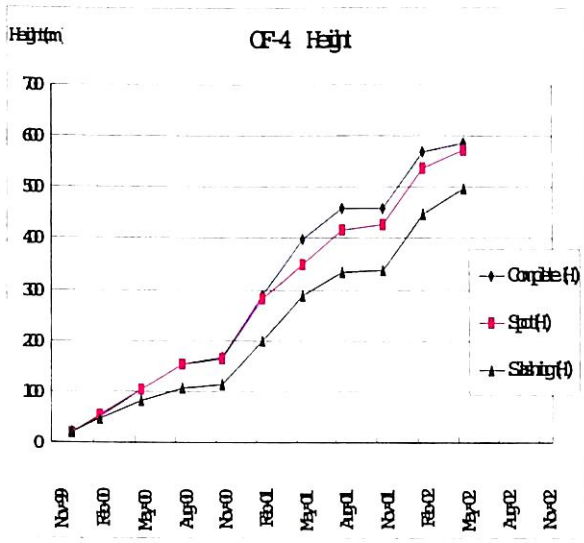
(2) Growth performance

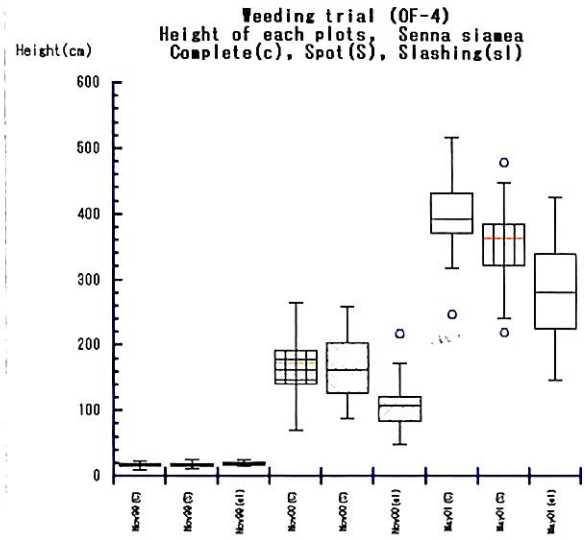
Data collected one year after planting showed that, except on-farm A where treatments were not correctly maintained, notable significant difference were observed in other trial plots between different treatments. In later years, also, the trend of growth gap between treatments continued to become wider.

In on-farm 5 where intercropping was not done, the effects of different weeding techniques were very clear. The growth (height, root color diameter) of tree under complete weeding plot was about two times bigger than that of spot weeding plot and about four times bigger than that of slashing plot.

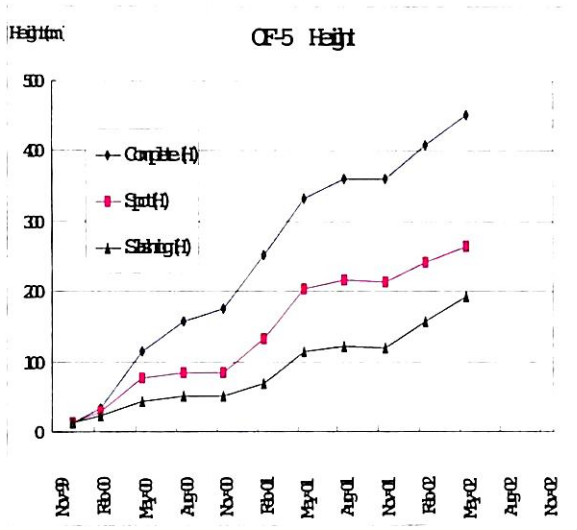
On-farm 4 where treatments were not correctly maintained (In the time of short rains, farmer mistakenly weeded all the treatments uniformly strip weeded), there was no significant difference between complete weeding and spot weeding, but there was significant difference between complete/spot and slashing.

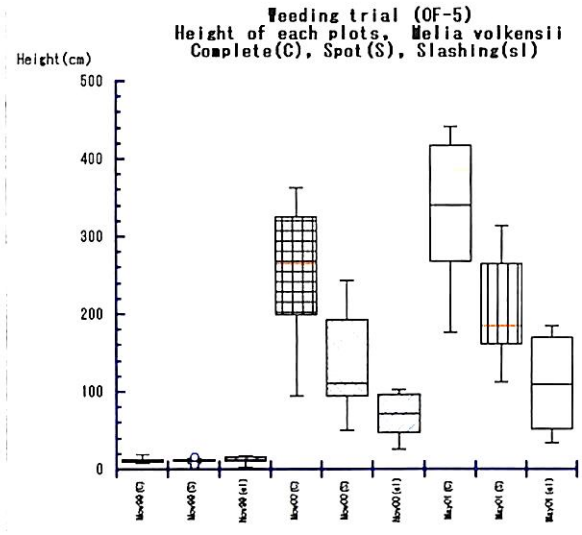
In on-farm 2F where farmer intercropped trees and cowpea, which covered the trial plot fully during the long rain season, notable significant difference was registered between each treatment. Growth of trees 9 months after planting (before they were browsed) showed that the growth of trees in complete weeding plot was quit big followed by spot and the slashing. During the dry period, the growth of trees under spot weeding and slashing reduced while that of trees of trees under complete weeding continued.



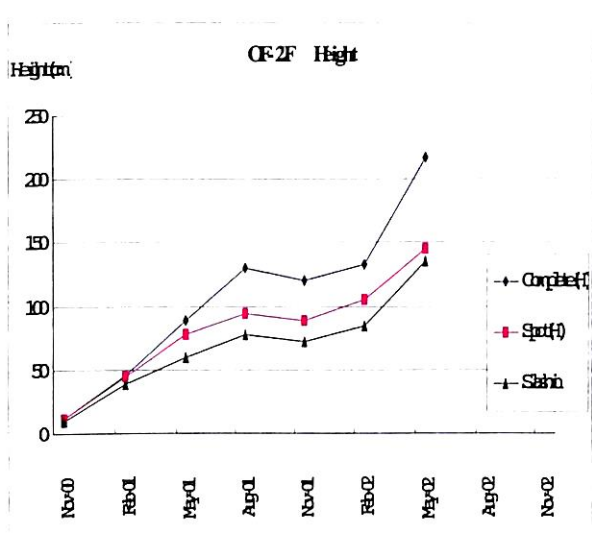


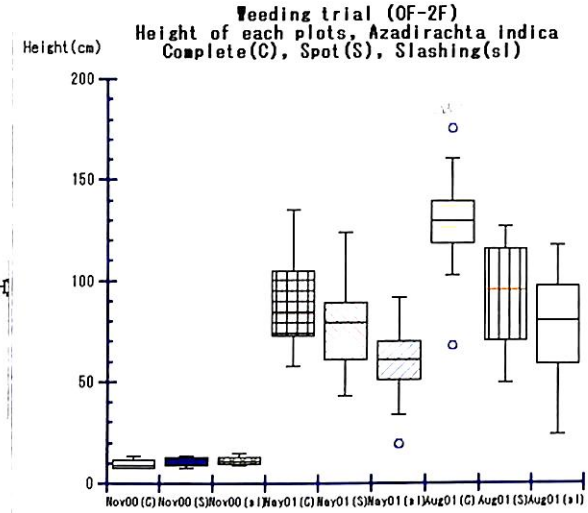
initial 12 months 18 months





initial 12 months 18 months





initial 6 months 9 months

Discussion

Through the on-farm results the difference of survival rate of each individual treatment could not be confirmed, but there was clear difference between treatments on growth performance.

The following notable points were observed.

Even though in the slashing plot, the survival rate was more than 90%, major mortality cause was due to damage during slashing and browsing.

Surprisingly the effect of complete weeding was quit big and not only during the rain season but also during the dry period whereby continuous growth was confirmed.

The difference of trees growth in each individual treatment in three years after planting the trend continued to become big. Even though, it has not been confirmed whether the difference gap between the treatments will reduce/disappear or not.

The growth difference of trees under slashing plot, in on-farm 4 where the treatments were not correctly maintained (2m strip weeding done in all treatments during rain season) was very big compared to slashing plots in other trial sites. Two years after planting the average trees height was more than 3m. Also in this trial plot, the growth of trees in different treatments was very low.

And also in on-farm 4, one year after planting, there was no difference between complete weeding and spot weeding on tree growth.

The trees under complete weeding plot in the on-Farm 2F, where the cow pea was intercropped with trees and covered all the treatment plot, showed significant difference between treatments.

Also in on-farm 2F, where trees were browsed by goats during the dry period, five months later (after the end of long rain season), the browsed trees recovered well and they attained the height they had before browsing. The transformation of browsed trees was observed (coppicing, deformed tree shape).

The effects of complete weeding

1) Through complete weeding, the consumption of moisture and nutrient by weeds is reduced.
2) Through cultivation, the capacity of water infiltration and aeration is enhanced in the soil.

Considering the above complete weeding effects reduction of competition between weeds with trees for moisture and nutrients was thought to be big than enhancement of moisture and aeration into the soil for better trees establishment.

The reason why the growth of trees under complete weeding plot was better than spot and slashing in the initial stages (1 year) is that, through complete weeding, there is removal of weed roots so the competition of trees and weeds decrease and growth of planted trees roots accelerated. For the above reason, the growth of trees under slashing plot in on-farm 4 (2m strip weeding done in all treatments during rain season) continued well despite the fact that only one time the incorrect treatment was done. In other words the strip weeding, which was conducted, removed the weeds roots thus availing moisture to extend planted trees roots. During the rain season, the planted trees roots could grow faster than weeds.

Based on the above factors, the following are recommended to the farmers.

1) In case a farmer does not conduct intercropping,

   Spot weeding or strip weeding is recommended in the first two to three years.

   The spot/strip weeding area should be between 1m 1.5m radius/distance from the tree (about two time of the tree height). The spot/strip weeded area should be expanded depending on the trees growth. Weeding should be conducted two or three times in the long rains and one to two times in short rains.

2) In case a farmer intends to carry out intercropping,

   The weeding should be conducted fully and on time, as this is one of the agricultural practices. Also following things should be noted.

   Crops should be planted more than one meter away from planted trees. Weeds near the trees should be removed two or three times in long rain and one or two times in short rains.

Conclusion

It is evident from the above results that weeding may be more important for the farmer to get good survival and growth for the trees planted in arid and semi-arid area. Since tree may not be first priority to the farmers. Introduction of subsistence crops can make farmers invest their labor on trees weeding as they weed their agricultural crops. Controlling of weeds is therefore an important tree/ plantation management practice. The need to control weeds should not be restricted to the first year of planting or establishment alone but should continue until canopy has closed and can suppress potential competing weeds.

And also complete weeding improves the growth of the planted trees which helps to control browsing (high height beyond goats reach) by livestock and physical damage from oxen-plough.

Appendix – 1

Progress

Nov. 1999 Experiment plots were established in OF-4,5. *Azadirachta indica/ Senna siamea* were planted.

Apr. 2000 Farmer of the OF-4 conducted 2m wide strip weeding uniformly by mistake.

Nov. 2000 Experiment plot was established in OF-2F. *Azadirachta indica* was planted.

Nov. 2000Jan. 2001 Farmer of OF-4 intercropped maize while farmer of OF-2F intercropped cowpeas during the long rain season.

Sep. 2000 All trees were severely browsed by goats in OF-2F.

(Out line of care/ problem)

Trial Site	Weeding/ inter-cropping	Protection/ damage	Others
OF-4	Farmer inter-cropped maize in each rain season. Lack of proper treatment conducted by farmer in Apr.2000/2001. (2m wide strip weeding conducted to all the treatments uniformly in Apr. 2000/ to Spot weeding plots in Apr. 2001)	There was no browsing problem.	
OF-5	No inter-cropping. Treatments (complete weeding, spot weeding, slashing) properly conducted on time in each rain season.	There was no browsing problem.	
OF-2F	Farmer inter-cropped cowpeas in the first long rain season. (Complete weeding plots fully covered by cowpeas)	All trees were severely browsed by goats in Sep.2000.	

Pruning trial

1 Objective

To apply and verify the effect of pruning height for trees planting in ASALs in different areas and condition (farm land) using farmers' resource.

2Site description

Two trial sites were established in 2000 in Central and Mutomo division, as shown below.

(Farmer's name & location)

Trial Site	Farmer's name	Location	Year Established
OF-2A	Mr. Joseph Mukwekwe	Miambani / Central Div.	2000
OF-2F	Mr. Stephen Mulatya	Ikanga / Mutomo Div.	2000

(Site description)

Trial Site	Area(ha)	Eco-Zone	Slop (Terrace)	Soil	Rainfall (mm)	Pre-site condition
OF-2A	0.14	-1	12° (none)	Luvisols PH 7.0-7.7 Effective depth 120cm Soil texture SL	Oct.2000855	Grazing land
OF-2F	0.13	-1	0° (none)	Luvisols PH 6.7-8.1 Effective depth 90cm Soil texture SL	Oct.2000553	Farm land

3 Method

(1) Experimental design

The experiments were set as Complete Randomized Block Design (CRBD) with three treatments (2/3 height pruning, 1/2 height pruning and control (no pruning)) and replicated twice. Survival rate and growth (height, root collar diameter and DBH) were assessed every three months and monitoring was conducted every month to assess the trees growth performance.

(2) Planting and tending techniques

In the case where the trial site was virgin, clearing of bushes and removal of all the existing vegetation was conducted. After that, planting and tending techniques were carried out.

1) Planting (including site preparation)

Site preparation oxen-plough

Spacing was 3.5m x 3.5m

Hole size 45cm x 45cm

Water harvesting structure W-shape micro-catchments (V-shape in 1998/1999)

Trial species; *Melia volkensii*

2) Tending

The following tending techniques were conducted.

Repair of broken micro-catchment.

Complete weeding (Two times in each rain season.)

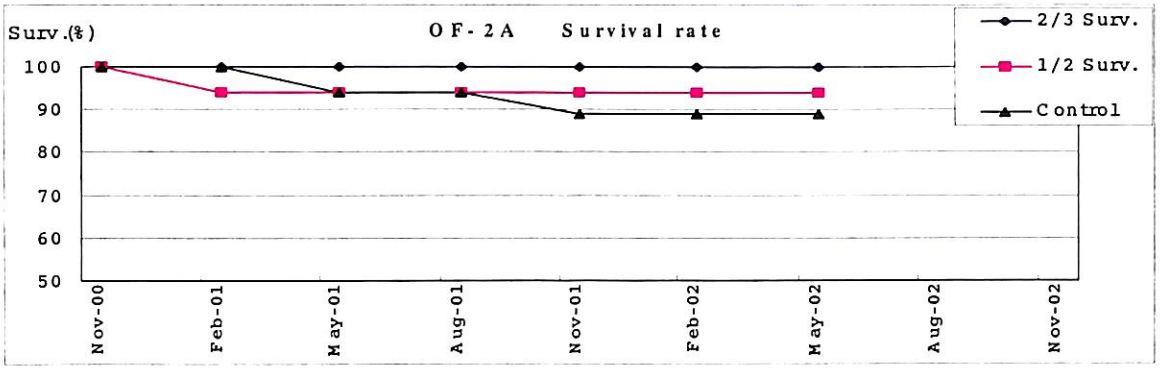
Basically, farmers were supposed to manage the trial plots, but where there was need, the project workers assisted on the management of the sites.

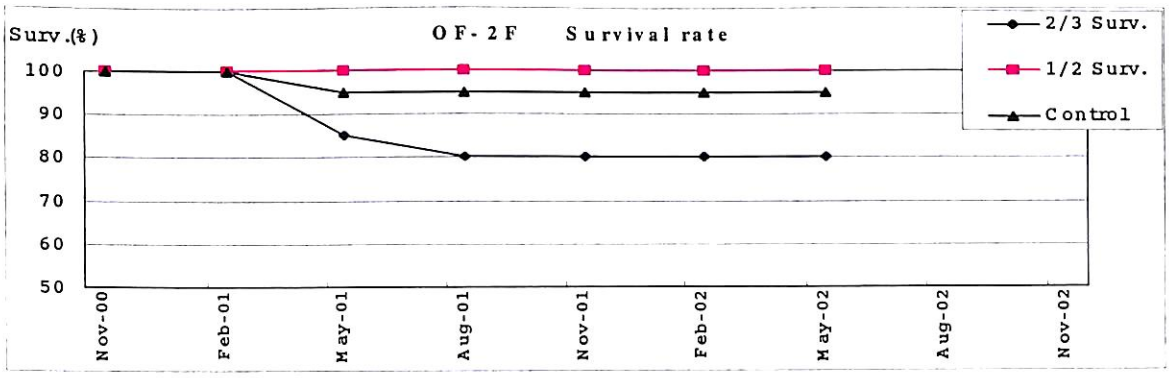
Results

(1) Survival rate

One year after planting, the survival rate of the planted trees showed that on-farm 2A ranged from 88% to 100% and on-farm 2F ranged from 80% to 100%. There was no significant difference between different treatments and different trial sites. But generally, the survival rate was good in all the sites. Until one year and six months, the survival rate remained almost the same.

Immediately after planting, several trees died due to water logging in both trial sites and replanted trees survived well and three months after planting, the survival rate remained at 100% but, after the end of short rain season, some trees infected by certain fungus disease which affected mostly 2/3 pruning height plot in On-farm 2F. The number of trees, which may have died due to drought in both trial sites, was not confirmed.

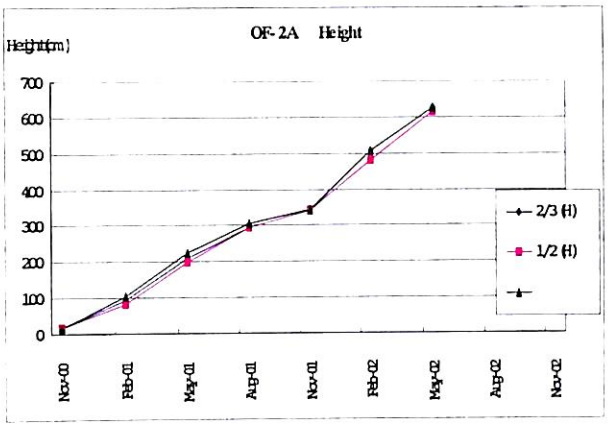


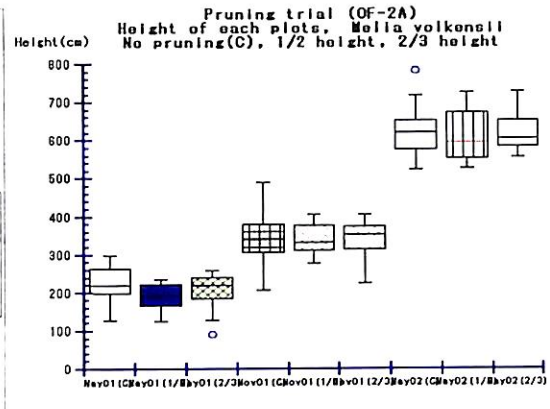


(2) Growth performance

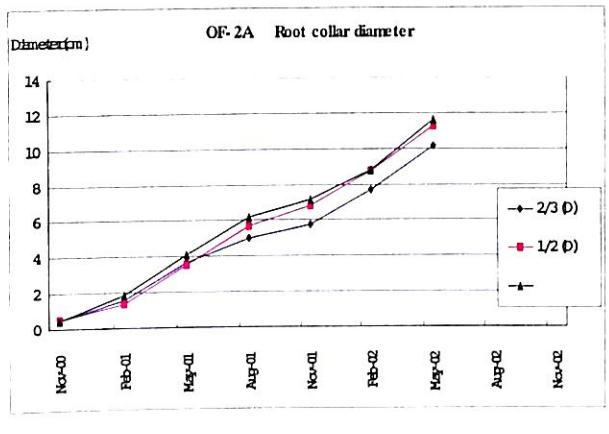
Collected data from trees planted one year and six months showed that there was no significant difference between different treatments on growth in both trial sites. There was no difference especially on height. It was also observed that, where the pruning height was high, the root color diameter was smaller than unpruned trees. On the other hand, the DBH for high pruned trees was almost the same as unpruned trees.

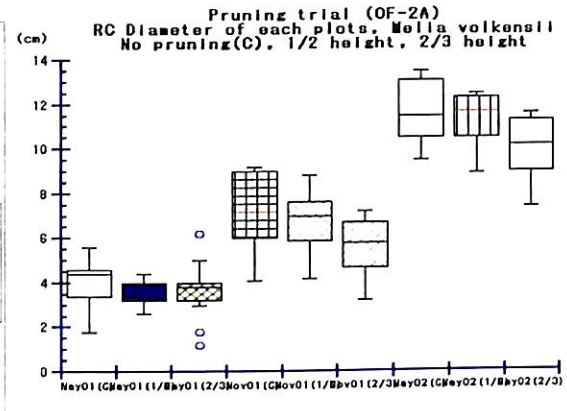
The difference of trees performance in both trial sites was so big. In the on-farm 2A, one year after planting average height was 4m and average root collar was 7cm. One year and 6 months, average height was 6 m and root collar diameter was 11cm.





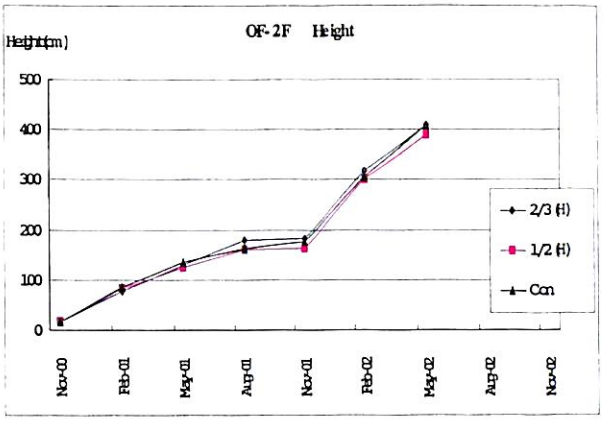
6 months 12 months 18 months

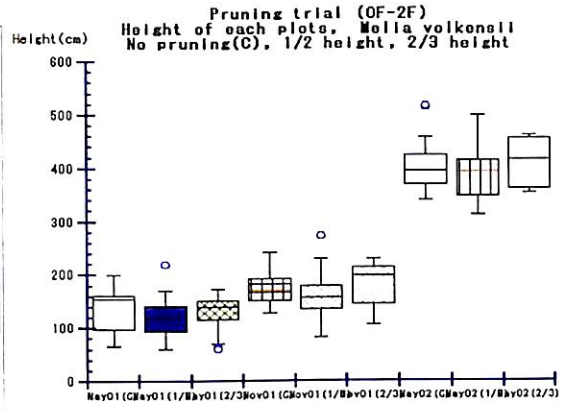




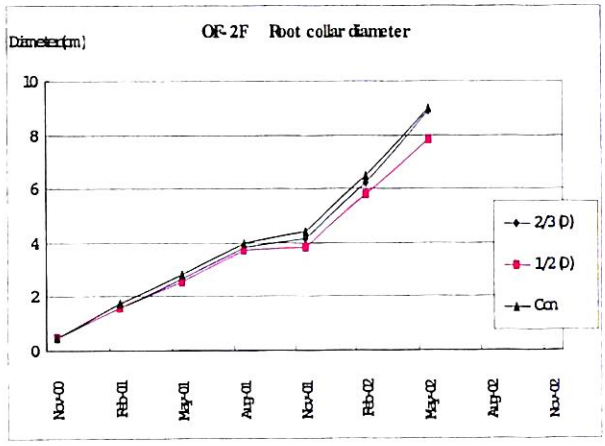
6 months 12 months 18 months

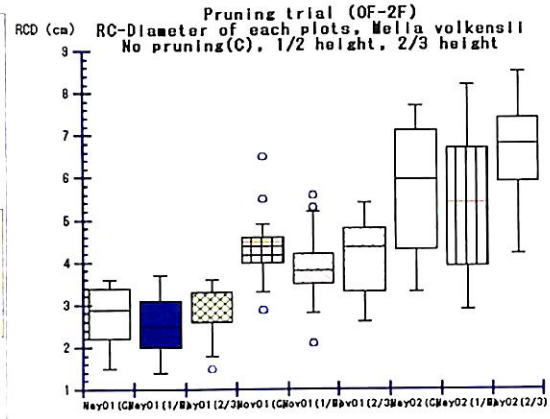
On the other hand, in on-farm 2F, one year after planting average height was 2m and root collar diameter was 4cm. And also, in one and 6 months after planting, average height was 4m and root collar diameter was 8cm.



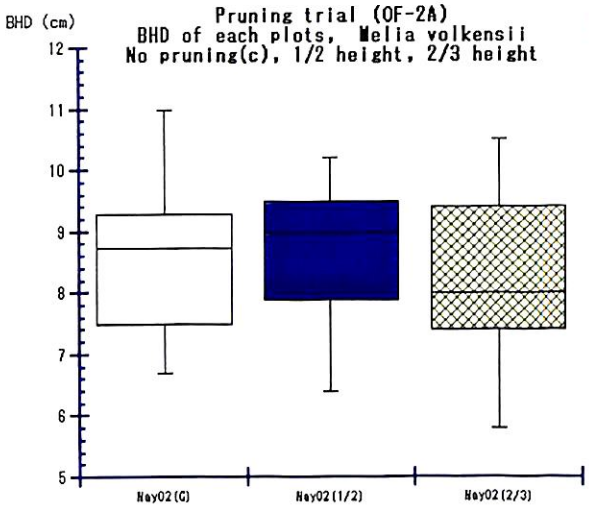


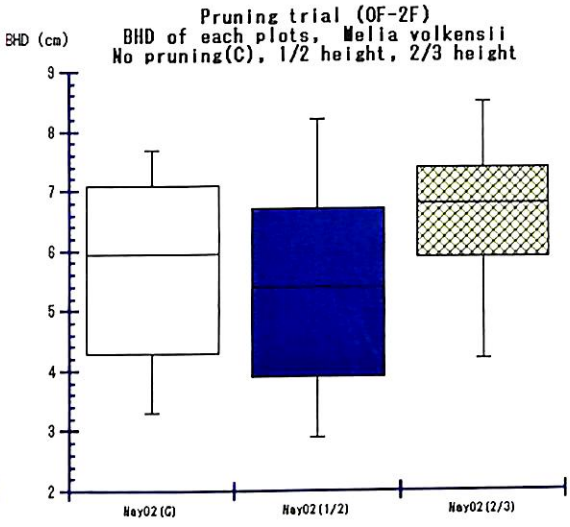
6 months 12 months 18 months





6 months 12 months 18 months





18 months 18 months

(3) Others

From the observation of the on-farm trial sites, on the pruned plots, clean and straight stems could be observed while unpruned plots trees contained a lot of branches and the bole was short. If the main purpose of the planted trees is timber production, early pruning is very necessary.

In the first year after planting, the trees under pruned plots in on-farm 2A continued to grow even during the dry period while on the other hand, unpruned trees showed signs of water stress through shading of the leaves. In the on-farm 2F, trees under all the treatments shaded their leaves due to water stress.

OF-2A Pruning plot (1/2 of height)

OF-2A Control plot (no pruning)

Discussion

From the collected data one year and six months after planting, the effects of different pruning height was not observed on survival and growth. Also, from the same data, *Melia volkensii* which was used as a candidate species, it was observed that there was no significant difference between different tree pruning rate on survival and trees height.

According to the pruning trial conducted at the pilot forest *Senna siamea* was used. *Senna siamea* is an exotic species and it is highly affected by die back especially during the severe drought. May be the die back could be its natural mechanism of reducing its water loss. Therefore, by pruning the amount of water lose through leaves (evapotranspiration) is minimized thus controlling the die back. So, the pruned trees can grow (height/ DBH) faster than unpruned ones.

In the case of *Melia volkensii* which is indigenous deciduous tree, and well adaptable in this harsh climatic condition, once moisture content decrease in the soil, the tree can immediately drop its leaves to control its water lose and thus avoid die back. So, the die back effect does not influence reduction of trees height through die back..

Also in case, the main purpose of planting *Melia volkensii* is timber, pruning becomes very important because unpruned *Melia volkensii* produce a lot of branches, which reduce the growth of the DBH and the useful bole remain short.

৴ Conclusion

Through the collected data and observation, it was confirmed that pruning does not affect trees height. Also it was noted that if trees are pruned at high level, the root collar diameter becomes small while the DBH grow bigger. Therefore, pruning is essential for production of timber.

The collected data was for only one year and six months old trees and was not enough to use for final analysis. So, data collection and monitoring should be continued.

Appendix – 1

Progress

Nov. 2000 Experiment plots were established in OF-2A,2F. *Melia volkensii* was planted.
Dec. 2000 Several trees died due to water logging. Replanting was conducted.
Nov. 2000Feb. 2001 OF-2A intercropped maize while OF-2F intercropped cowpeas during the long rain season. Both farmers had enough harvest. Complete weeding was conducted on time.

Mar. 2001May. 2001 Complete weeding conducted on time.
May. 2001 First pruning was conducted.
Sep. 2001 Some trees were browsed by goats in OF-2F.
Dec. 2001 Second pruning was conducted.
Dec. 2001May 2002 Complete weeding conducted on time in each rain season.
Apr. 2002 Third pruning was conducted.

(Out line of care/ problem)

Trial Site	Weeding/ inter-cropping	Protection/ damage	Others
OF-2A	Farmer inter-cropped maize in the first long rain season. Farmer/ project worker conducted complete weeding/ repair of catchments in both rain season.	There was no browsing problem.	First pruning conducted as per the plot design in May 2001.
OF-2F	Farmer inter-cropped cowpeas in the first long rain season. (All plots fully covered by cowpeas) Farmer/ project worker conducted complete weeding/ repair of catchments in both rain season.	Some trees were browsed by goats in Sep.2001.	First pruning conducted as per the plot design in May 2001.

Melia planting site trial

1 Introduction

Melia volkensii is one of the most important tree species found in Arid and Semi-arid areas (ASALs). Because of its high growth, high drought tolerance, high resistance to termite and production of valuable timber, the species was chosen as one of the recommended species for farm forestry establishment.

But, young planted *Melia volkensii* trees are highly affected by water logging which affected some of the on-farm trial sites. To address the above problem, an experiment was set, to improve the survival rate of planted trees.

Objective ; To determine the suitable planting position of M. volkensii on micro-catchments to cope with poor survival rate due to water logging during the establishment period.

2Site description

One trial site was established in 2000 in Chuluni division as shown below.

(Farmer's name & location)

Trial Site	Farmer's name	Location	Year Established
OF-2C	Mr. Jackson Mutua	Nzambani / Chuluni Div.	2000

(Site description)

Trial Site	Area(ha)	Eco-Zone	Slop (Terrace)	Soil	Rainfall (mm)	Pre-site condition
OF-2C	0.16	-1	23° (none)	Luvisols PH 6.3-7.6 Effective depth 130cm Soil texture SCL	Oct.2000912	Farm land

3 Method

(1) Experimental design

The experiment was set as Complete Randomized Block Design (CRBD) with three treatments (planted in upper side of the micro-catchments, planted in lower side of the micro-catchments, planted inside the micro-catchments) and replicated twice. Survival rate and growth (height and root collar diameter) were assessed every three months and monitoring was conducted every month to confirm the trial trees growth performance.

(2) Planting and tending techniques

1) Planting (including site preparation)

Site preparation oxen-plough

Spacing was 3.5m x 3.5m

Hole size 45cm x 45cm

Water harvesting structure W-shape micro-catchments

Trial species; *Melia volkensii*

2) Tending

The following tending techniques were conducted.

Repair of broken micro-catchments.

Complete weeding (Two times in each rain season.)

Basically, farmers were supposed to manage the trial plots, but where there was need, the project workers assisted on the management of the sites.

Results

(1) Survival rate

After the trees establishment (mid of November 2000), by 1st of January 2001 a lot of trees died due to water logging especially where trees were planted inside the catchment (control), the survival rate was about 25%. On the other hand, the survival rate of tree which were planted on the upper side of the micro-catchment was 67% and those planted below the micro-catchment was 60%. All the trial plots were replanted three times (28th Nov. 2000, 8th Dec. 2000 and 12th Jan. 2001) and the total number of the planted trees was 56. About 64%(36) of the planted trees in the control plot died (the reason why the replanted number in control is bigger than total number of the control plot (24)) was that, the replanting was repeated many times due to high mortality rate.

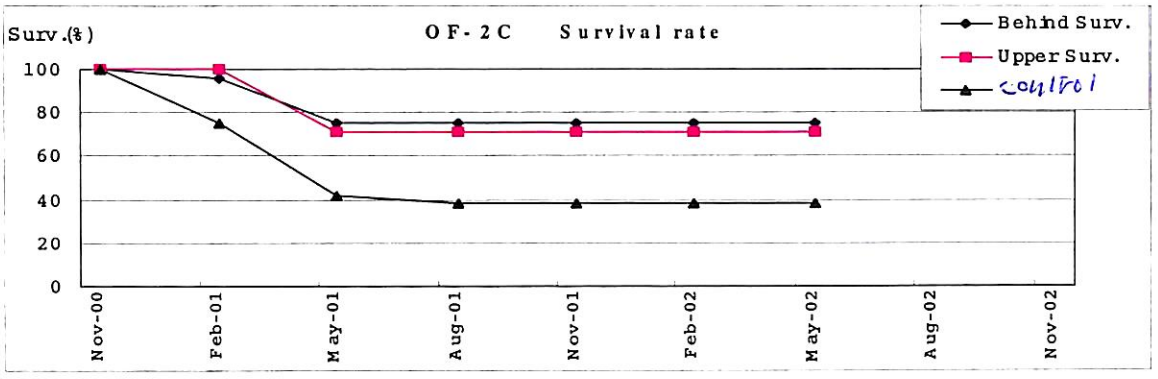
The survival rate of trees in three months after planting was 75% including the replanted trees in the control plot while the survival rate of trees under upper and below the catchment plots were 100% and 96% respectively.

The survival rate of the planted trees during the same period, excluding the replanted trees, the control had 25% while other plots (upper/below) had 67% and below 58% respectively.

Also the survival rate of the planted trees in six months after planting, control had 42% (including replanted trees) and on the other hand, upper side had 71% and below 75%.

Later, the survival rate remained constant in all the treatments. Between the third month and six months after planting about 18 trees died and 95% out of the dead trees were from the replanted trees.

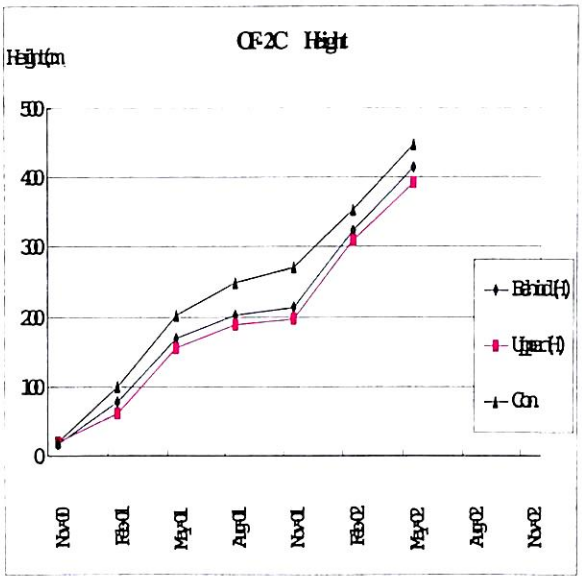
Behind Water-catchment(W/C) Upper W/C Control(inside W/C)

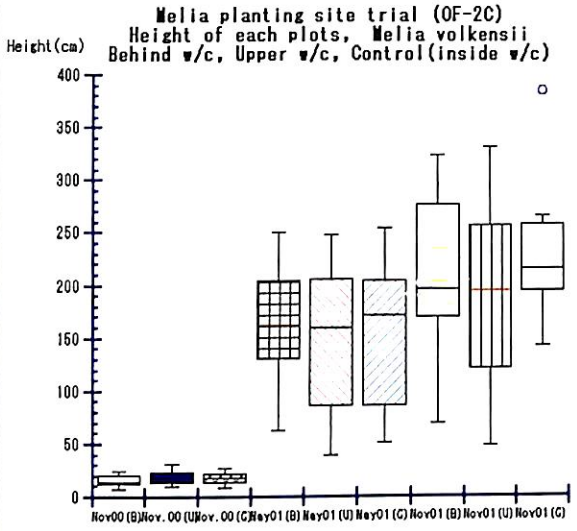


(2) Growth performance

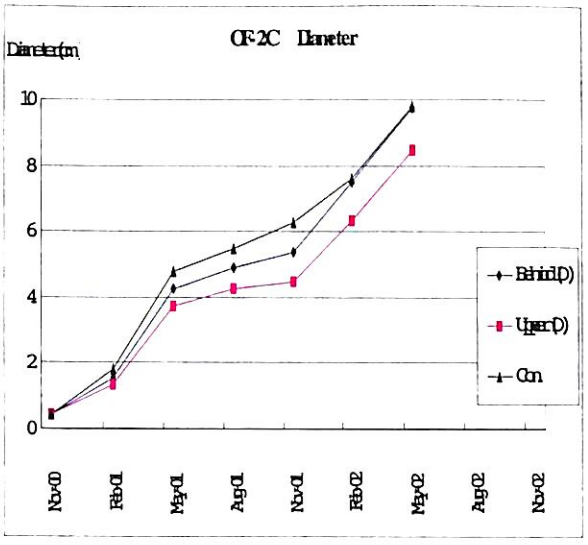
Through the data collected in one year and six months after tree establishment, there was no significant difference between different treatments on growth (height and diameter).

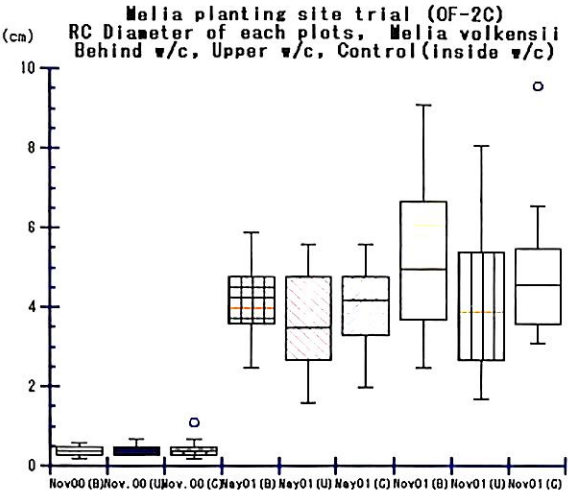
The growth of trees planted under control plot performed better than other treatments. The suggested reasons for this results was that the number of trees in the control plot was small and only healthy and big trees remained.





Initial 6 months 12 months





Initial 6 months 12 months

Discussion

From this trial, it was observed that, by avoiding water logging the survival rate of *Melia volkensii* trees could drastically improve. The significance difference observed between different treatments was due to poor infiltration and drainage of the clay soils resulting in water logging. So, the survival rate of upper side planting and below side planted was almost the same.

There was no notable significant growth performance difference between upper side planting and below side planting.

The growth rate comparison trials using the same tree species also gave same result above 80% confirming these results of this trial (see the growth rate comparison trial report).

By avoiding water logging, *Melia volkensii* can be planted even though clay soil type.

Conclusion

Micro-catchments are important for trees planted in ASALs, but the results of this experiment indicated very well that *Melia volkensii* is not favorable to water logging. So, it is suggested that *Melia volkensii* should be planted away from the micro-catchments, preferably on the lower side of the micro-catchments.

Appendix – 1

Progress

Nov. 2000 Experiment plots were established in OF-2C. Melia volkensii was planted.
Nov. 2000Jan. 2001 Farmer intercropped maize/ beans between the trees during the long rain season. Farmer/ Project worker conducted complete weeding/ repair of micro-catchments.

Dec. 2000 Many Melia volkensii planted inside the micro-catchments (ordinary planting position) died due to water logging. Replanting was conducted.
Mar. 2001May 2001 Farmer intercropped maize/ beans between the trees during the long rain season. Farmer/ Project worker conducted complete weeding/ repair of micro-catchments.

(Out line of care/ problem)

Trial Site	Weeding/ inter-cropping	Protection/ damage	Others
OF-2C	Farmer inter-cropped maize/ beans in both rain season in the first year. Farmer/ project worker conducted complete weeding/ repair of catchments in both rain season.	There was no browsing problem.	Many Melia volkensii especially planted inside the micro-catchments (ordinary planting position) died due to water logging. Replanting conducted in Dec. 2000.

Growth rate comparison trial

1 Introduction

Before the extension of tree planting technologies to the farmers, it is important to understand, major trees characteristics such as tolerance to drought, termite resistance, growth performance and suitable soil type for specific species.

In addition, it is also important to confirm basic farm information concerning rainfall amount, soil type etc. which can be used to guide during the selection of specific species for that particular area.

History of tree planting activities in Kitui area, which is semi arid, was not adequate to guide on where specific species could be established, and therefore growth rate comparison trial was made to verify characteristics of most recommended species in different areas. *Melia volkensii* and *Senna siamea* were established in all the 15 on-farm trial sites.

Objectives ; Comparing the growth of *Melia volkensii* and *Senna siamea* in relation to rainfall and soil type on different sites within the project operation area.

2Site description

Considering the rainfall amount, soil type etc. within the project area, 15 on-farm trial plots were established. The growth rate comparison experiments of *Melia volkensii* and *Senna siamea* were set on all 15 On-farm trial sites in 2000 in Kabati, Chuluni, Central and Mutomo division, as shown in table-1.

Table-1

Trial Site	Farmer's name	Location	Year Established
OF-A	Mrs. Lucia Mutava	Kyangwithya West / Central Div.	Nov. 2000
OF-B	Mrs. Monica Nguli	Matinyani / Kabati Div.	Nov. 2000
OF-C	Mr. David Ngonde	Nzangathi / Chuluni Div.	Nov. 2000
OF-1	Mr. Justus Makanda	Maliku / Central Div.	Nov. 2000
OF-2	Mr. George Mwaniki	Kathivo / Kabati Div.	Nov. 2000
OF-3	Mrs. Ruth Kyama	Kisasi / Chuluni Div.	Nov. 2000
OF-4	Mrs. Christine Kitema	Mbitini / Chuluni Div.	Nov. 2000
OF-5	Mr. Gabriel Ndetei	Ikanga / Mutomo Div.	Nov. 2000
OF-6	Mr. Manundu Nyamai	Ikanga / Mutomo Div.	Nov. 2000
OF-2A	Mr. Joseph Mukwekwe	Miambani / Central Div.	Nov. 2000
OF-2B	Mrs. Florence Mwinzi	Katutu / Kabati Div.	Nov. 2000
OF-2C	Mr. Jackson Mutua	Nzambani / Chuluni Div.	Nov. 2000
OF-2D	Mr. Boniface Mutia	Kisasi / Chuluni Div.	Nov. 2000
OF-2E	Mr. Bartholomew Mutia	Ikanga / Mutomo Div.	Nov. 2000

OF-2F	Mr. Stephen Mulatya	Ikanga / Mutomo Div.	Nov. 2000

The rainfall amounts for the 15 sites ranged from 483mm to 912mm with Luvisols being the dominant soil type as shown in Table-2.

Table-2

Trial Site	Area(ha)	Eco-Zone	Slop (Terrace)	Soil	Rainfall (mm)	Pre-site condition
OF-A	0.03	-2	25° (none)	Luvisols PH 6.7-7.3 Effective depth 65cm Soil texture SCL	Oct.2000523	Grazing land
OF-B	0.06	-2	5° (none)	Regosols PH 8.4-8.8 Effective depth 50cm Soil texture SL	Oct.2000483	Grazing land
OF-C	0.05	-2	4° (exist)	Cambisols PH 5.0-6.2 Effective depth 110cm Soil texture SL	Oct.2000831	Farm land
OF-1	0.05	-2	1° (none)	Luvisols PH 6.2-8.7 Effective depth 110cm Soil texture SL	Oct.2000610	Grazing land
OF-2	0.06	-2	5° (none)	Luvisols PH 6.3-7.1 Effective depth 73cm Soil texture SCL	Oct.2000518	Farm land
OF-3	0.05	-2	5° (exist)	Cambisols PH 6.9-9.5 Effective depth 125cm Soil texture SL	Oct.2000734	Farm land
OF-4	0.05	-2	1° (none)	Luvisols PH 6.2-7.2 Effective depth 62cm Soil texture SL	Oct.2000(789)	Grazing land
OF-5	0.07	-1	0° (none)	Luvisols PH 5.6-7.4 Effective depth 80cm Soil texture SL	Oct.2000787	Grazing land
OF-6	0.04	-1	0° (none)	Luvisols PH 6.2-8.7 Effective depth 40cm Soil texture SCL	Oct.2000679	Grazing land
OF-2A	0.05	-1	0° (none)	Luvisols PH 7.0-7.7 Effective depth 120cm Soil texture SL	Oct.2000855	Grazing land
OF-2B	0.04	-2	12° (none)	Vertisols PH 7.0-7.4 Effective depth 90cm Soil texture SL	Oct.2000542	Farm land
OF-2C	0.04	-1	23° (none)	Luvisols PH 6.3-7.6 Effective depth 130cm	Oct.2000912	Farm land

				Soil texture SCL		
OF-2D	0.04	-2	23° (exist)	Acrisols PH 5.8-7.0 Effective depth 80cm Soil texture SL	Oct.2000900	Farm land
OF-2E	0.06	-1	0° (none)	Ferralsols PH 5.4-6.7 Effective depth 140cm Soil texture SCL	Oct.2000782	Grazing land
OF-2F	0.05	-1	0° (none)	Luvisols PH 6.7-8.1 Effective depth 90cm Soil texture SL	Oct.2000553	Farm land

3 Method

(1) Design/Treatment

The 15 on-farm growth rate comparison trial plots were established in the 15 on-farm trial sites. The method of establishment and tending were uniformly conducted (from planting to weeding) in all sites.

Survival rate and growth (height and root color diameter) were assessed every three months and monitoring was conducted every month to assess the trial trees growth performance.

(2) Planting and tending techniques

In case where the trial site was virgin, clearing of bushes and removal of all the existing vegetation was conducted. After that, planting and tending techniques were carried out.

1) Planting (including site preparation)

Site preparation ----- oxen-plough

Spacing was 3.5m x 3.5m

Hole size 45cm x 45cm

Water-harvesting structure ----- W-shaped micro- catchments

2) Tending

The following tending techniques were conducted.

Repair of broken micro-catchment.

Weeding ----- Complete weeding (Two times in each rain season.)

Inter cropping ----- Farmer were requested to put two lines of maize and one line of beans between the trees and keep at least 1m away from the planted trees.

Basically, farmers were supposed to manage the trial site, but where there was need, the project workers assisted on the management of the site.

4Results

The two trial species were evaluated in terms of

drought tolerance and termite resistance

growth performance

suitable soil type

suitability for intercropping

Drought tolerance and termite resistance.

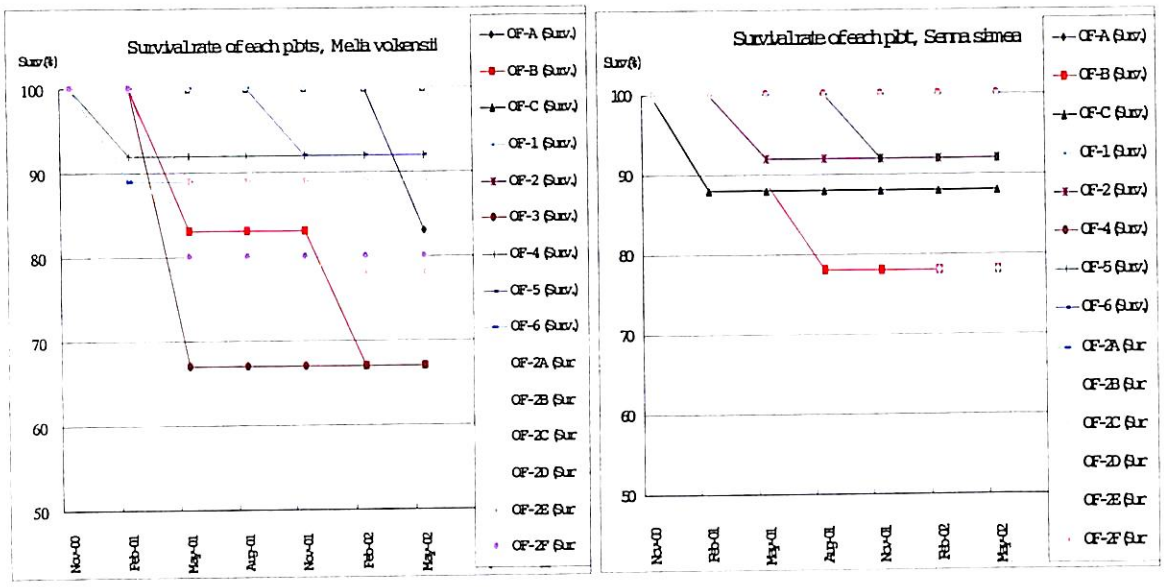
First year after planting (October 2000 to September 2001) the accumulated rain fall amount ranged between 480mm to 910mm within the on-firm trial sites. This period was considered to be one of the driest year as compared to previous years but through intensive site management (especially complete weeding) the survival rate of *Melia volkensii* and *Senna siamea* in all the trial sites ranged between 67% to 100%.

Two notable observations were made.

Main cause of *Melia volkensii* mortalities was contributed by water logging, but establishing the *Melia volkensii* below the micro-catchment (away from water logging) improved the survival rate drastically.

There was no significant difference between the two species on survival rate in all the trial sites.

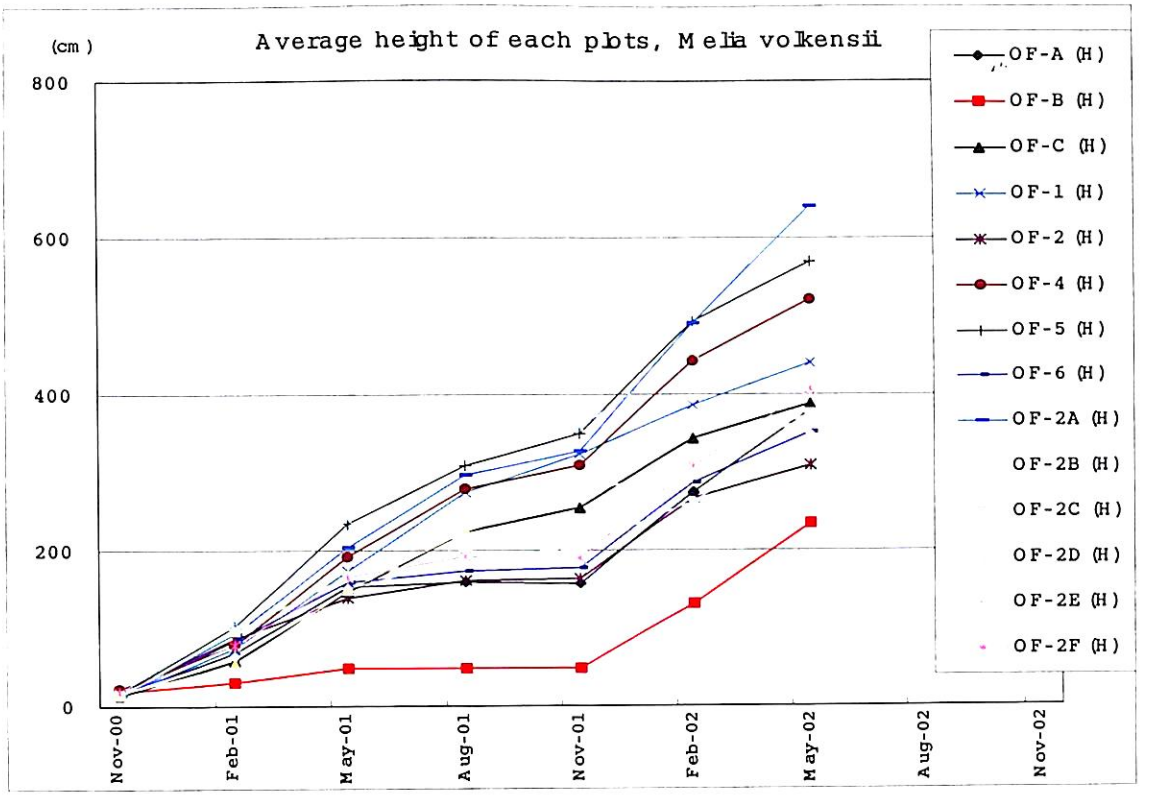
Through this trial it was confirmed that both species can be recommended to be planted even under harsh climatic conditions.

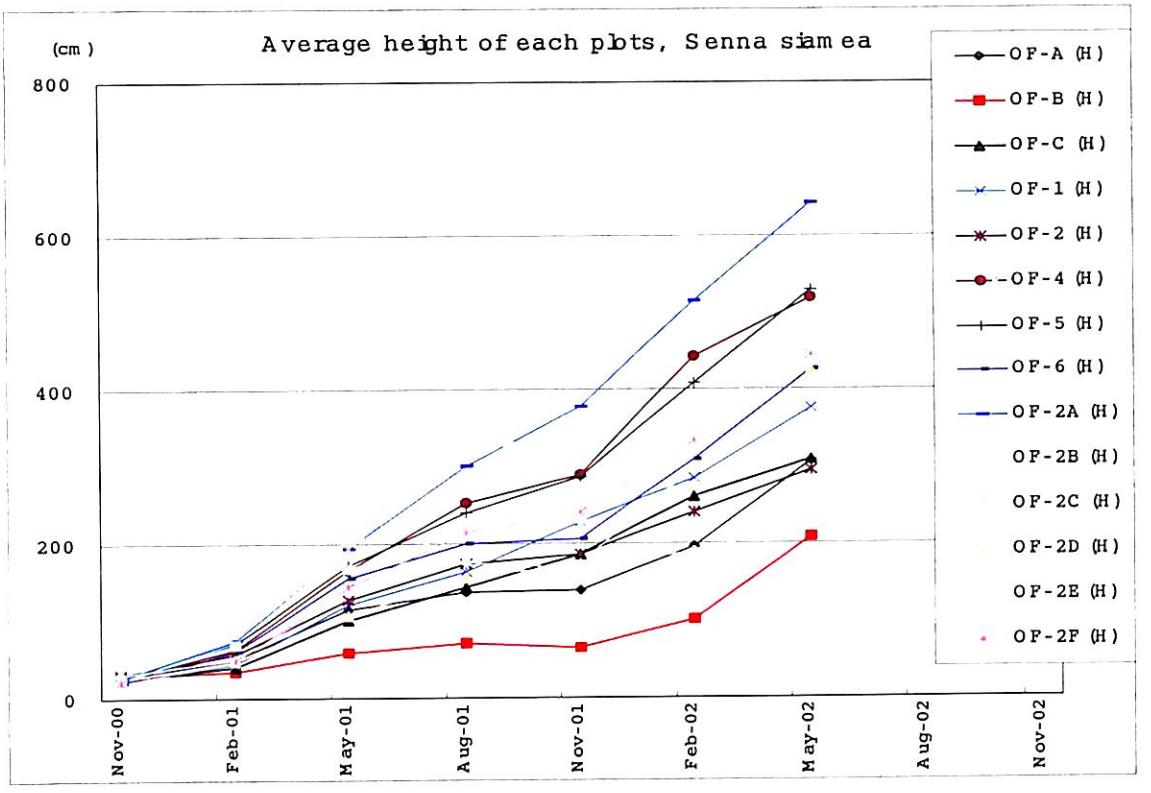


Growth performance.

The average height of both *Melia volkensii* and *Senna siamea* in the individual trial plots in ranged from 2m to 6m, with overall average height of 4m. The highest growing tree had over 8m. The average root collar diameter of *Melia volkensii* in each trial site ranged from 4cm to 11cm, with overall average diameter of 8cm. For *Senna siamea*, the average root collar diameter ranged from 4cm to 10cm, with overall average diameter of 7cm. It was observed that, the growth performance of *Melia volkensii* was faster than *Senna siamea*.

Despite the fact that, the range of growth performance of both species was quite wide depending on the site condition but generally during the initial stage, the growth was impressive.


Average height of each plots, Melia volkensii
(cm)
800
600
400
200
0
Nov-00
Feb-01
May-01
Aug-01
Nov-01
Feb-02
May-02
Aug-02
Nov-02
OF-A (H)
OF-B (H)
OF-C (H)
OF-1 (H)
OF-2 (H)
OF-4 (H)
OF-5 (H)
OF-6 (H)
OF-2A (H)
OF-2B (H)
OF-2C (H)
OF-2D (H)
OF-2E (H)
OF-2F (H)


Average height of each plots, Senna siamea
(cm)
800
600
400
200
0
Nov-00
Feb-01
May-01
Aug-01
Nov-01
Feb-02
May-02
Aug-02
Nov-02
OF-A (H)
OF-B (H)
OF-C (H)
OF-1 (H)
OF-2 (H)
OF-4 (H)
OF-5 (H)
OF-6 (H)
OF-2A (H)
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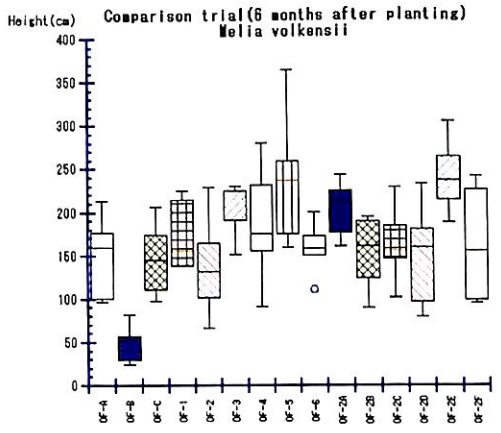
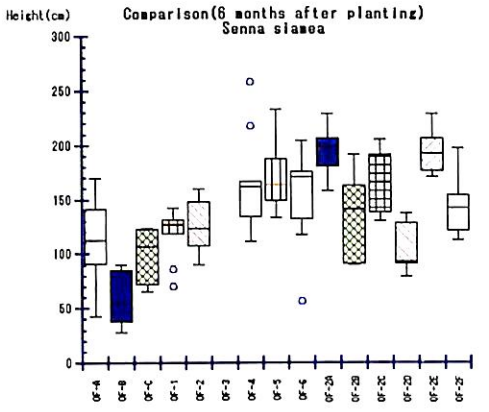
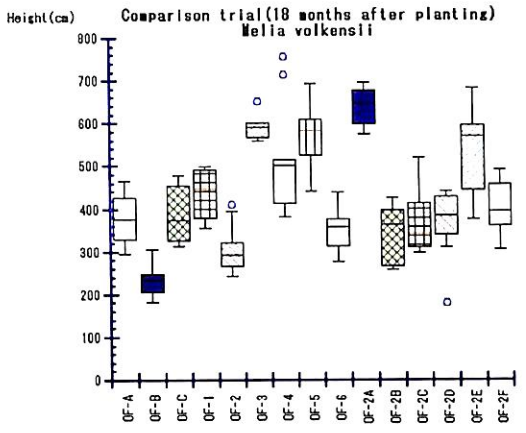
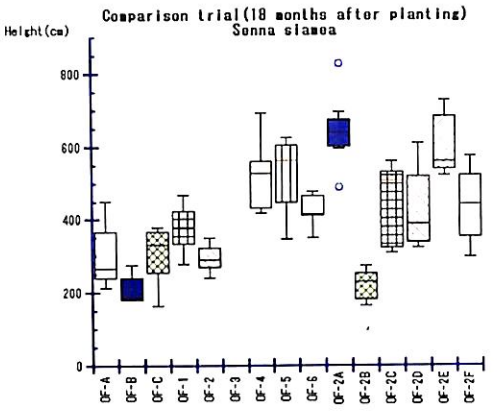
OF-2F (H)

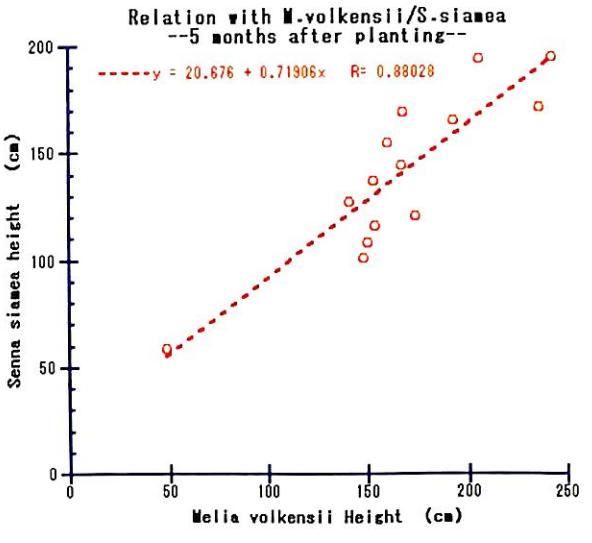


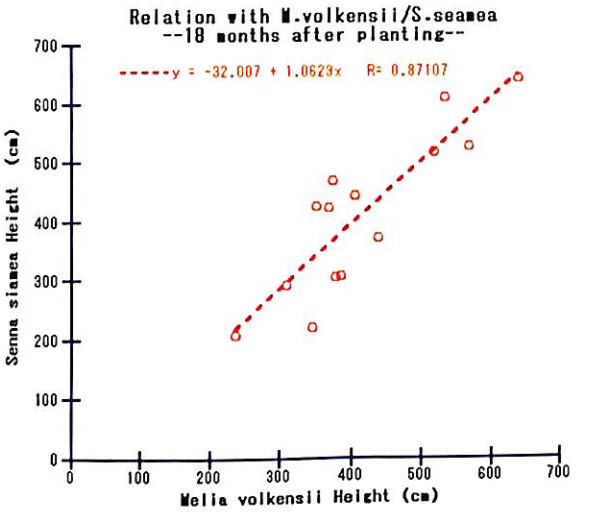






It was also observed that, the growth relationship between *Melia volkensii* and *Senna siamea* was very strong during the initial stage (1 year and 6 months after planting). The trial site, which showed good growth performance of *Melia volkensii*, in such a site good growth of *Senna siamea*, was also observed. Through this observation it was confirmed the significance relationship in height between *Melia volkensii* and *Senna siamea.*





In addition, through the monitoring of the on-farm trials, the following were observed.

) During the dry periods, some sites trees continued to grow while in others the growth immediately stopped until rain season.

) It was observed that fast growing trees during the rain season also performed better during the dry period while the slow growing trees during the rain season also grew slowly during the dry spell.

) It was also noted that growth of planted trees improved with increased rainfall amount.

Suitable soil type

There was not observed between the different soil types on growth performance, except on-farm B which had Regosols soil type.

Because the planting and tending were uniformly conducted in all trial sites, it could be suggested that the growth difference between individual sites came from different site conditions especially rainfall amount. Though, the two species could be recommended for ASALs, but high rainfall amounts and fertile sites are more suitable for them.

Suitability for intercropping

In the first year after planting in both rain season, except on-farm C all other sites were intercropped (two line maize and one line of beans were planted. Farmers were also required to plant their crops 1m away from the planted trees). Almost all farmers planted their crops 1m away from the planted trees, growth of the trees was quite good and at the same time they could harvest a lot of yield (1-2 ton per hectare during long rain season). But few farmers planted their crops close to the trees between 20cm to 30cm, and in such a case, it was observed that the growth of trees were low and yields of the crops were also low. (Table-3)

Also intercropping trial was conducted in the pilot forest. It was confirmed that, if the crop density was less than 50% the competition of the planted trees with crops was minimal. If the two lines of maize and one line of beans could be converted into crop density, the crop density in all the trial sites could be less than 50% (crop cover). This factor led to successful results.

Second year after planting, in 7 trial sites intercropping was conducted. Both rain seasons, the trial areas received enough rains, and farmers could get a lot harvest. But, due to competition between crops and planted trees for moisture and sunlight, in the several trial sites, the yield of the planted crops decreased.

Through this observation, in the case of 3.5m x 3.5m spacing, fast growing species such as *Melia volkensii*, planted intercropping can do well only within two years. Also, where farmers want to intercrop for longer period the planted trees should be wider to limit the competition for moisture, nutrients and sunshine.

Table-3

	Maize (kg/ha)		
	Mar. 2001 (A)	Mar. 2002 (B)	(B)/(A) %
OF-1		1,092	
OF-2	831	957	1.15

OF-3		950	
OF-4	878		
OF-5	1,199		
OF-2B		411	
OF-2C	673		
OF-2D	760		
OF-2E	1,685	1,234	0.73
Average	1,004	929	

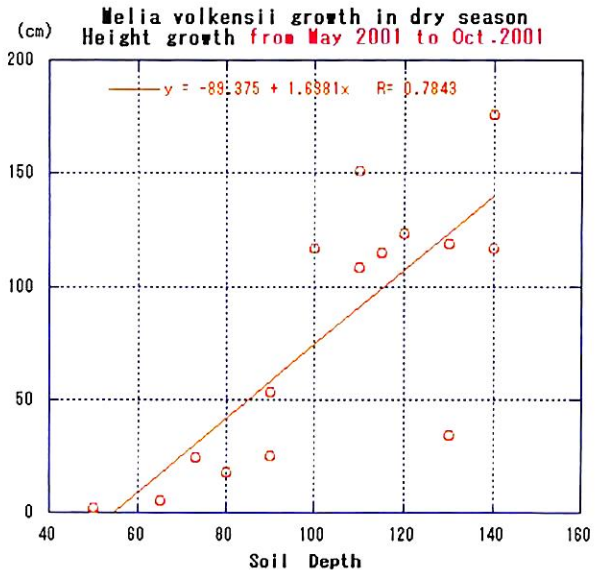
Discussion

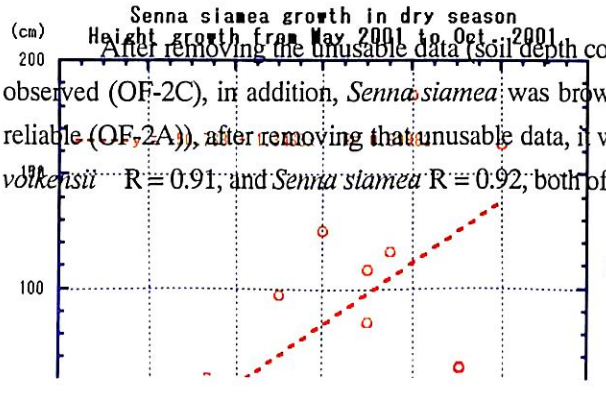
(1) Analysis of the reasons, which made some trees, grow even during the dry spell.

First dry period after planting from May 2001 to October 2001 (6 months), it was observed that trees in some trial sites continued to grow while in others the growth stopped immediate when the drought started. This behavior was observed in both trial species. The suggested reasons for the above observation was that, (The main observation was based on trees height)

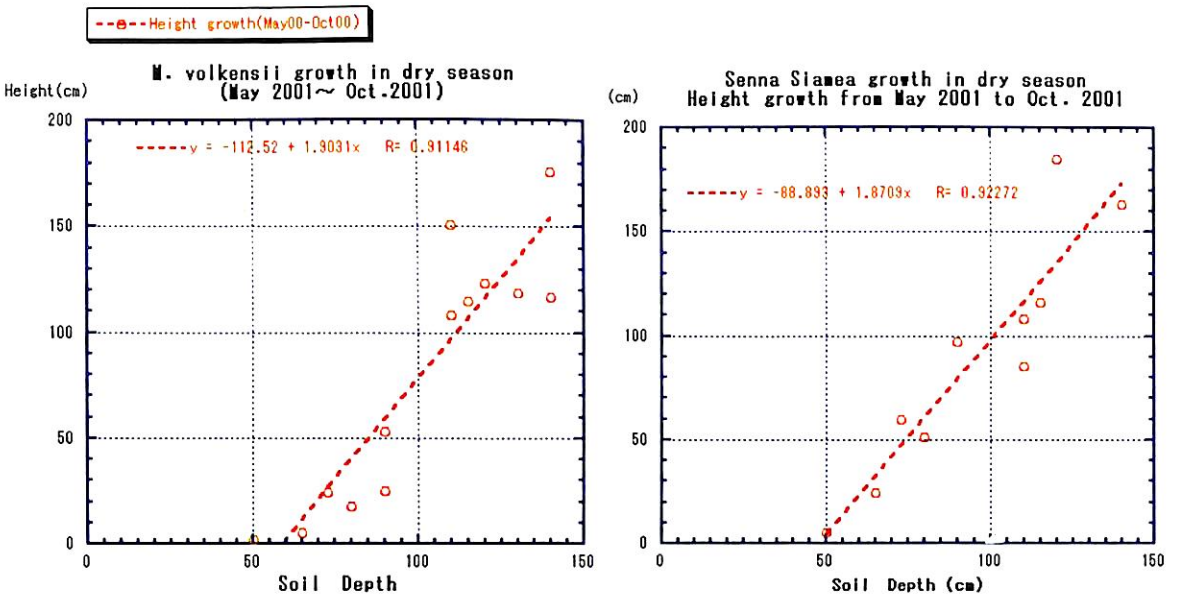
Strong interrelation between soil depth and growth of trees during the dry period.

It was confirmed that, there was strong interrelation between different soil depths (until rock basement or above C layer) and different trees growth during the dry period in different trial sites. (*Melia volkensii* R = 0.78, and *Senna siamea* R = 0.69, both of them were highly significant.)





After removing the unusable data (soil depth could not be confirmed (OF-4), a lot of run off water was observed (OF-2C), in addition, *Senna siamea* was browsed (OF-2B), there was collected data which was not reliable (OF-2A)), after removing that unusable data, it was noted that the interrelation became stronger. (*Melia volkensii* R = 0.91, and *Senna siamea* R = 0.92, both of them interrelation was highly significant.)

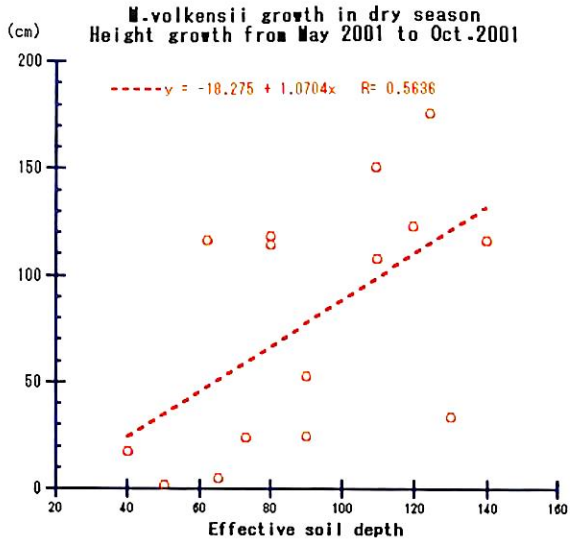


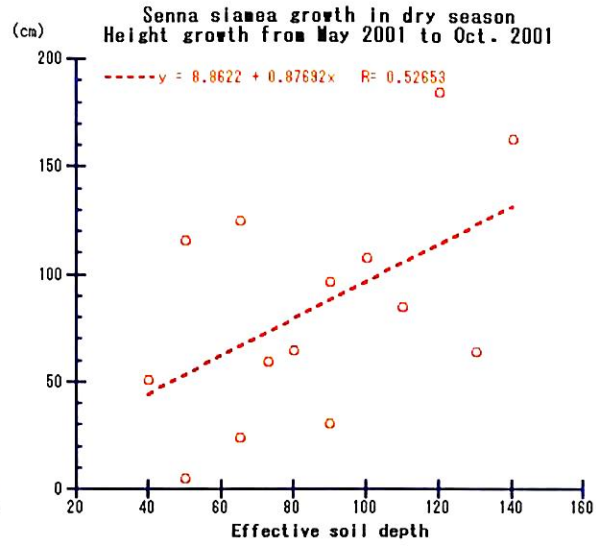
From the distribution graph (interrelation) the following conclusions can be made.

1) In the case of the same soil depth, the growth of trees during the dry period. The growth of trees during the dry period, the growth of *Senna siamea* was little bit higher than *Melia volkensii*.
2) In the case of shallow soil, the growth of trees during dry period was very low. Where the depth of soil was less than 50cm to 60cm, the growth of trees was not expected (*Melia volkensii 60cm, and Senna siamea* 50cm).
3) The growth is relative to soil depth, in the case where soil depth is 100cm, *Melia volkensii* will grow 80cm and *Senna siamea* will grow 100cm, and in the case the soil depth is 140cm, *Melia volkensii* will grow 150cm and *Senna siamea* will grow 170cm, the growth is respectively expected.

But, if calculation is made using effective soil depth (in agricultural sector, this depth is thought to be important for crops growth), *Melia volkensii* and *Senna siamea* showed only some interrelation. (*Melia volkensii* R = 0.56, and *Senna siamea* R = 0.53)

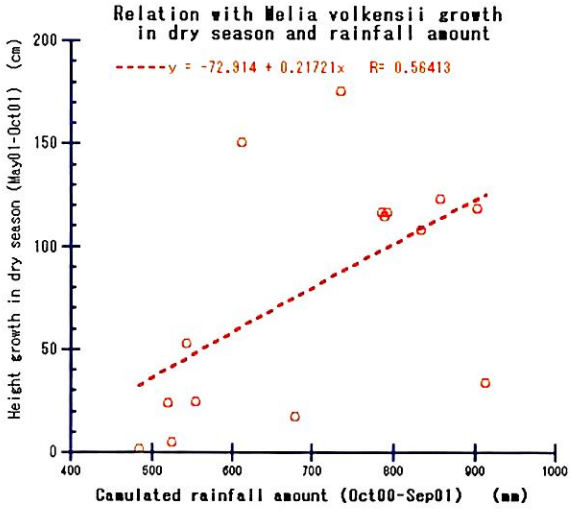
The reason for the above was that, in the case of a tree the root can extent up to deep layer where crops root cannot and also tree roots can penetrate through hard soil layers and therefore trees roots in each trial sites were thought to have extended into deep soil layers (beyond effective soil depth). Because of this reason, in the case of a tree, the soil depth (which can contain moisture) is more important than effective soil depth. This mechanism realized high interrelation between soil depth and trees growth during the dry period.

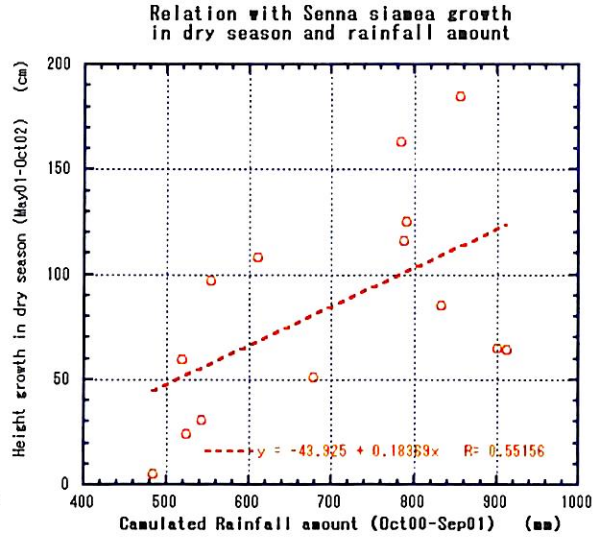




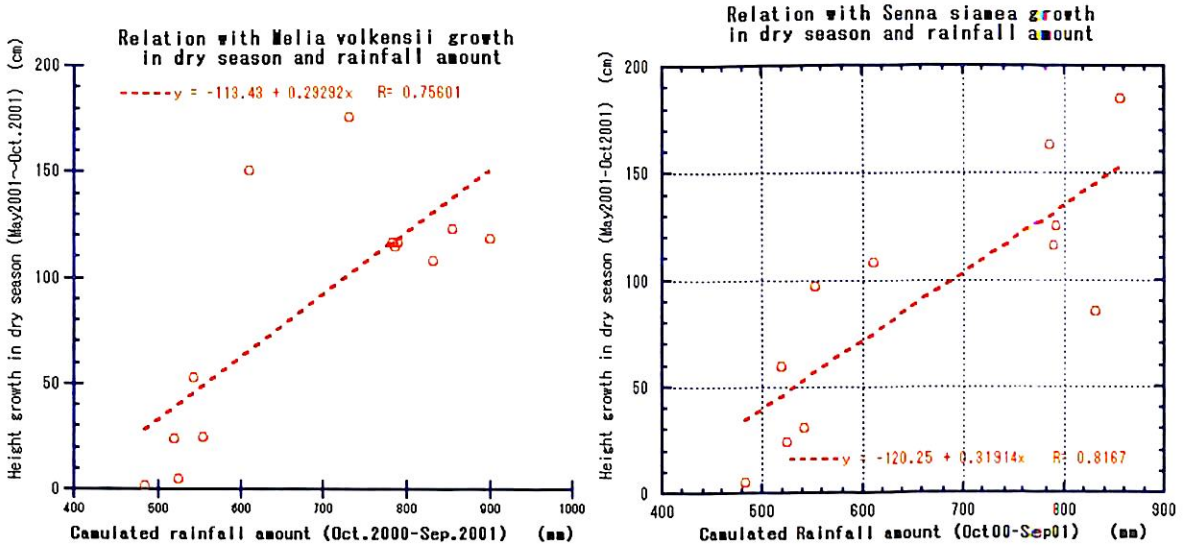
High interrelation between accumulated rain fall amount and trees growth during the dry period.

It was confirmed that, there was high interrelation between trees growth (each trial site) during the dry period and accumulated rainfall amount (October 2000 to September 2001). (*Melia volkensii* R = 0.56, and *Senna siamea* R = 0.55, both of them interrelation were significant.)





And also as under above some unusable data were omitted (a lot of run off water was observed OF-6 and OF-2C, in adition, concerning) *Senna siamea* the collected data were not reliable OF-2D). After omitting the unusable data, high interrelation between trees growth during dry period and accumulated rainfall amount could be observed. (*Melia volkensii* R = 0.76, and *Senna siamea* R = 0.81, the interrelation was significant for both species.)



Through the distribution graph the following things were observed.

1) In the case rain fall amounts are the same, the growth of *Senna siamea* during the dry period is little bit higher than that of *Melia volkensii.* (About 10cm20cm)
2) Where the accumulated rainfall amount is small, the growth of trees during the dry period also drastically decrease, and if amount of accumulated rain fall amount is less than 400mm, both species stop growing during dry spell.
3) In proportion to rain fall amount the growth of trees during the dry period increases. In the case where the rainfall amount is 500mm, *Melia volkensii* grows 35cm and *Senna siamea* grows 40cm. And in the case, the rainfall amount is 800mm, *Melia volkensii* grows 120cm while *Senna siamea* grows 135cm (during the dry period) this growth is respectively expected.

Through those analyses, the interrelation between soil depth and growth during the dry period was higher than interrelation between accumulated rainfall amount and trees growth during dry period. The suggested reason was that, if soil is shallow, even if rainfall amount is big, the soil can not retain enough moisture for trees use during the dry period and where soil is deep, a lot of moisture can be retained into the soil thus providing more moisture to the trees which lead to improved trees growth performance during the dry spell.

The growth performance of trial trees during the dry period.

Based on average height in each trial site, it has already been discussed the interrelation between soil depth and trees growth during dry period and interrelation between accumulated rainfall amount and trees growth during the dry period. Considering the individual trees growth performance (height) during the dry period.

To understand the individual trees growth performance during the dry period in detail, trees growing performance can be categorized into two groups A and B. A belong to the group which stops growing after the end of rain and B belong to the group which continue growing even after the rains (dry spell). The sites which fall under group are of OF-A,B,2,6,2B,2C and 2F, and those which fall under group B are OF-C,1,3,4,5,2A,2D and 2E.

The following graphs show the average heights of categorized individual trees growth group. It also

shows the trees growing history of the categorized trees growing groups.

Table- group A

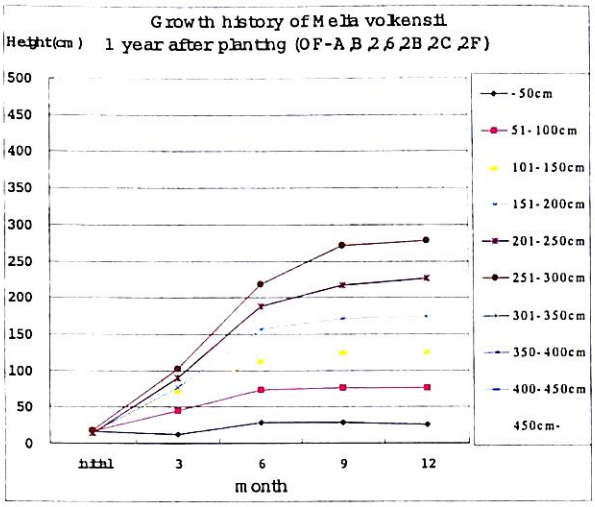
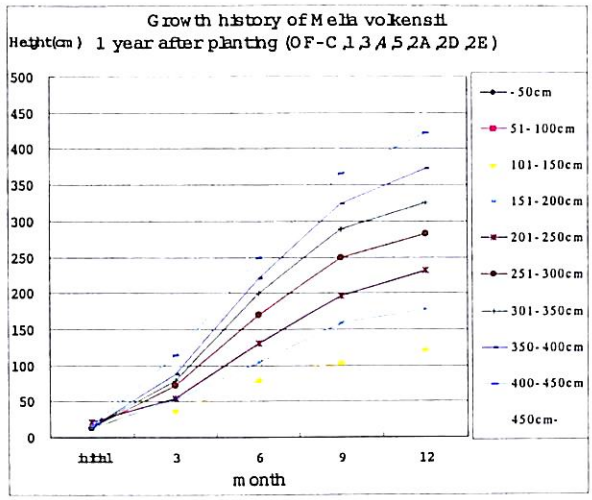


Table- group B



From these graphs under group A, at the time of beginning of dry period, first of May (6 months after planting) the trees whose height was less than 1.5m, the growth of trees during the dry period was almost zero, and even though the trees with height of about 2m, the growth during the dry period was about 0.5m only.

Concerning the group B, the trees growth during the dry period could be observed in the all classes. The class of trees whose height was less than 1.5m at 6 months after planting, about 1m growth was noted. The group of trees whose height was 2.5m at 6 months after planting, the growth during the dry period was surprisingly about 2m. The growth of trees at six month after planting showed that the higher the trees, the higher the growth during the dry period. In this group, even at the end of the dry season, the trees continued to grow.

The reasons, which may have contributed, to the above trend were that, concerning the group A, except OF-C and 2C, the soil depths are shallow and accumulated rainfall amounts were little, and so, the available moisture in the soil was not adequate. Therefore, the little moisture retained in the soil, may have been consumed by the trees and leading to *Melia volkensii,* shade leaves (enter dormancy). The reason why the growth performance was low in OF-C where soil was deep and rainfall amount was much, was that, the site was sloppy and soil contained a lot of clay and whenever there was heavy rain, a lot of run off was observed. It was considered that big amount of rainfall water was being lost through run off.

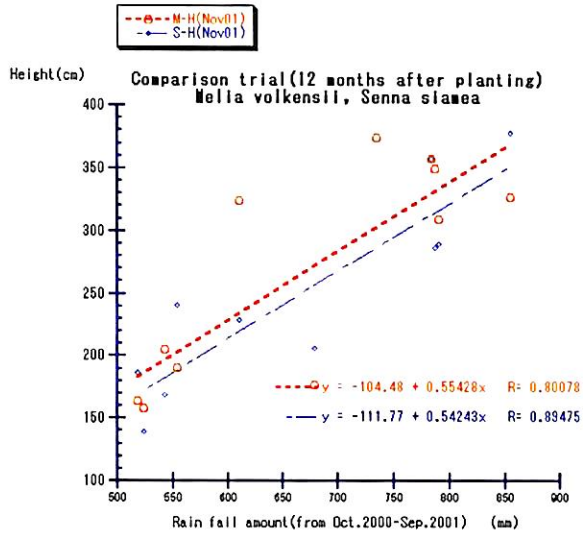
On the other hand, the good growth performance in group B, the soil depth in group B were deep and rain fall amounts were relatively much, so comparing with group A, the soil moisture in B was much than group A. The above factors may have contributed to the continues growth of the trees in group B.

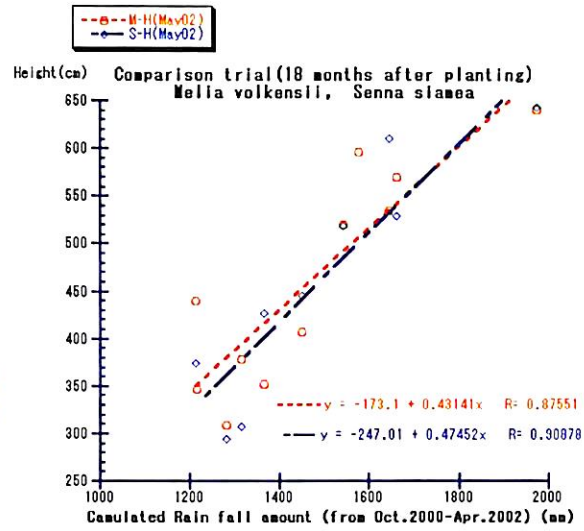
(2) The interrelation between growth and accumulated rainfall amount.

The inter relation between trees height and accumulated rainfall amount in each trial plot (6 months, 12 months and 18 months after planting data). After the analysis of interrelation between trees height and accumulated rainfall amount in some cases, it was observed that, in some trial sites there was no interrelation between rainfall amount and trees height. And therefore, such data was omitted (a lot of run off was observed OF-2C, poor soil Regosols OF-B, poor soil-sandy OF-C,2D and browsed by livestock OF-2B(only

Senna siamea)). After omitting the unusable data which came from the above factors, the analysis was done again and it was confirmed that there was strong interrelation.

	R	
	Melia volkensii	*Senna siamea*
6 months	0.85	0.90
12 months	0.80	0.89
18 months	0.87	0.91





Because it was confirmed that there was strong interrelation between growth (height) and rainfall amount, so, through estimated rainfall amount in each site, the growth of *Melia volkensii* and *Senna siamea* can be estimated during the initial stage.

It was observed that until 12 months after planting, if rain fall amount was the same, the higher of *Melia volkensii* was higher than *Senna siamea,* but 18 months later the height difference gap narrows down.

Conclusion

Through this comparison trial, it was confirmed that, the range of growth of *Melia volkensii* and *Senna siamea* was very big depending on site condition and rainfall amount. By conducting intensive site management (especially complete weeding) high survival rate and growth performance was achieved.

It was also confirmed that both species have high ability in drought tolerance, termite resistance and growth performance. Therefore, these two species can be recommended to the farmers found in drier areas where *Grevillea robusta* can not be planted.

It was confirmed that, until two years after planting, it was possible to carry out intercropping (maize, beans etc.) (in the case where spacing is 3.5m x 3.5m). It was also observed that, if crops are planted 1m away from the planted trees, the competition between the crops and trees can be minimized.

In addition, through the collected data, the following were observed.

Strong interrelation between rainfall amount and growth performance was confirmed.

The growth pf trees during the dry period, in some sites continued while in others stopped immediately after the rains.

Strong interrelation between soil depth and growth performance during dry period was confirmed.

Both tree species showed slowest growth rate in Regosols. Planting of both species on this soil type should not be recommended.

Appendix – 1

Progress

Nov. 2000 Experiment plots were established in all 15 On-farm sites. *Melia volkensii* and *Senna siamea* were planted.

Dec. 2000 Replanting of some *Melia volkensii* seedling was done in several On-farm sites.

Nov. 2000May 2001 Farmers (except OF-C) sowed maize/beans between the trees in both rain seasons. Complete weeding/ repair of micro-catchments were conducted on time.

Mar. 2001 Jul. 2001 All the 15 trial sites were fenced with barbed wire.

Sep. 2001 Some trees were browsed by livestock (goats) within the 3 trial sites (OF-B, 2B, 2F).

Nov. 2001Jan 2002 Six On-farm farmers (OF-A, 1, 2, 3, 2B, 2E) were sown maize/beans between the trees in the long rain season. Complete weeding/ repair of micro-catchments were conducted on time.

(Out line of care/ problem)

Trial Site	Weeding/ inter-cropping	Protection/ damage	Others
OF-A	Farmer inter-cropped maize (2 lines) / beans(1 line) / between the trees in both rain season in the first year. Complete weeding /repair of micro-catchments were conducted on time by farmer /project worker.	There was no browsing problem.	Many water-catchments were broken by strong run offs.
OF-B	Farmer inter-cropped maize (2 lines) / beans(1 line) / between the trees in both rain season in the first year. Complete weeding /repair of micro-catchments were conducted on time by farmer /project worker.	Dik-Dik, goats and cows browsed some trees during the dry season.	Many catchments were broken by strong run offs. (Farmer could not get any harvest.)
OF-C	No inter-cropping. Complete weeding /repair of micro-catchments were conducted on time by farmer /project worker.	There was no browsing problem.	
OF-1	----- same with OF-B------	----- ditto------	

Trial	Weeding/ inter-cropping	Protection/ damage	Others

Site			
OF-2	Farmer inter-cropped maize (2 lines) / beans(1 line) / between the trees in both rain season in the first year. Complete weeding /repair of micro-catchments were conducted on time by farmer /project worker.	Some trees got damage by oxen-plough.	
OF-3	----- ditto------	----- same with OF-C ----	
OF-4	----- ditto------	----- ditto------	
OF-5	----- ditto------	----- ditto------	
OF-6	----- ditto------	----- ditto------	Many catchments were broken by strong run offs.
OF-2A	----- ditto------	----- ditto------	
OF-2B	----- ditto------	Livestock(goats) severely browsed trees in Sep. 2001.	
OF-2C	----- ditto------	----- same with OF-C------	Many catchments were broken by strong run offs.
OF-2D	----- ditto------	----- ditto------	
OF-2E	----- ditto------	----- ditto------	
OF-2F	----- ditto------	----- ditto------	

Fruits establishment

1 Introduction

Fruits establishment is very important to the farmers because they can satisfy their nutritional needs and at the same time they can earn some income through sell.

To extent fruits planting to the farmers in ASALs, it is important to understand the characteristics of various individual fruits. Based on the known characteristics of the fruit species tree, such as resistance to drought, growth performance etc., it is easy to recommend suitable species to the individual farmers depending on site condition and available rainfall amount.

The most simple and effective method to confirm the most suitable fruit species for a particular area is by planting different fruit species in different areas (screening). In all the 15 on-farm site, *Mangifera indica* and *Citrus senensis* which are most popular fruits trees in the area were planted and monitored.

Also, in one trial site, indigenous (wild) fruit trees were introduced.

Objective; To test and find a suitable species of fruit trees using On-farm experimental plots in order to improve the living standard of the farmers through income generation and improving the nutritional feeding of the farmers.

2Site description

At the time of the all 15 on-farm trials establishments, in 1998, in 1999 and in 2000, in four divisions, namely Kabati, Chuluni, Central and Mutomo, fruits trees consisting of *Mangifera indica* and *Citrus senensis* were also introduced.

In November 1999, through farmers request wild fruits were introduced in on-farm 1.

(Farmer's name & location)

Trial Site	Farmer's name	Location	Year Established
OF-A	Mrs. Lucia Mutava	Kyangwithya West / Central Div.	1998
OF-B	Mrs. Monica Nguli	Matinyani / Chuluni Div.	1998
OF-C	Mr. David Ngonde	Nzangathi / Kabati Div.	1998
OF-1	Mr. Justus Makanda	Maliku / Central Div.	1999
OF-2	Mr. George Mwaniki	Kathivo / Kabati Div.	1999
OF-3	Mrs. Ruth Kyama	Kisasi / Chuluni Div.	1999
OF-4	Mrs. Christine Kitema	Mbitini / Chuluni Div.	1999
OF-5	Mr. Gabriel Ndetei	Ikanga / Mutomo Div.	1999
OF-6	Mr. Manundu Nyamai	Ikanga / Mutomo Div.	1999
OF-2A	Mr. Joseph Mukwekwe	Miambani / Central Div.	2000
OF-2B	Mrs. Florence Mwinzi	Katutu / Kabati Div.	2000
OF-2C	Mr. Jackson Mutua	Nzambani / Chuluni Div.	2000

OF-2D	Mr. Boniface Mutia	Kisasi / Chuluni Div.	2000
OF-2E	Mr. Bartholomew Mutia	Ikanga / Mutomo Div.	2000
OF-2F	Mr. Stephen Mulatya	Ikanga / Mutomo Div.	2000

(Site description)

Trial Site	Area(ha)	Eco-Zone	Slop (Terrace)	Soil	Rainfall (mm)	Pre-site condition
OF-A	0.06	-2	25° (none)	Luvisols PH 6.7-7.3 Effective depth 65cm Soil texture SCL	Oct.1998571 Oct.1999624 Oct.2000523	Farm land
OF-B	0.05	-2	5° (none)	Regosols PH 8.4-8.8 Effective depth 50cm Soil texture SL	Oct.1998627 Oct.1999899 Oct.2000483	Farm land
OF-C	0.08	-2	4° (exist)	Cambisols PH 5.0-6.2 Effective depth 110cm Soil texture SL	Oct.1998572 Oct.1999766 Oct.2000831	Farm land
OF-1	0.15	-2	1° (none)	Luvisols PH 6.2-8.7 Effective depth 110cm Soil texture SL	Oct.1999542 Oct.2000610	Grazing land
OF-2	0.04	-2	5° (none)	Luvisols PH 6.3-7.1 Effective depth 73cm Soil texture SCL	Oct.1999567 Oct.2000518	Farm land
OF-3	0.06	-2	5° (exist)	Cambisols PH 6.9-9.5 Effective depth 125cm Soil texture SL	Oct.1999646 Oct.2000734	Farm land
OF-4	0.06	-2	1° (none)	Luvisols PH 6.2-7.2 Effective depth 62cm Soil texture SL	Oct.1999636 Oct.2000(789)	Farm land
OF-5	0.06	-1	0° (none)	Luvisols PH 5.6-7.4 Effective depth 80cm Soil texture SL	Oct.1999546 Oct.2000787	Farm land
OF-6	0.08	-1	0° (none)	Luvisols PH 6.2-8.7 Effective depth 40cm Soil texture SCL	Oct.1999506 Oct.2000679	Farm land
OF-2A	0.06	-1	0° (none)	Luvisols PH 7.0-7.7 Effective depth 120cm Soil texture SL	Oct.2000855	Farm land
OF-2B	0.05	-2	12° (none)	Luvisols PH 7.0-7.4 Effective depth 90cm Soil texture SL	Oct.2000542	Farm land
OF-2C	0.06	-1	23° (none)	Luvisols PH 6.3-7.6 Effective depth 130cm Soil texture SCL	Oct.2000912	Farm land

OF-2D	0.05	-2	23° (exist)	Acrisols PH 5.8-7.0 Effective depth 80cm Soil texture SL	Oct.2000900	Farm land
OF-2E	0.05	-1	0° (none)	Ferralsols PH 5.4-6.7 Effective depth 140cm Soil texture SCL	Oct.2000782	Farm land
OF-2F	0.09	-1	0° (none)	Luvisols PH 6.7-8.1 Effective depth 90cm Soil texture SL	Oct.2000553	Farm land

3 Design/Treatment

(1) Design/Treatment

In all the 15 on-farm trial sites, *Mangifera indica* and *Citrus sinensis* were established.

Survival rate and growth (height) were assessed every three months and monitoring was conducted every month to confirm the fruit trees growth performance, browsing and any other problem.

(2) Method of planting and tending

In case where the trial site was newly opened, clearing of bushes and removal of all the existing vegetation was conducted. After that, planting and tending techniques were carried out.

1) Planting (including site preparation)

Site preparation ----- oxen-plough

Spacing was 7m x 7m (5m x 5m)

Hole size 60cm x 60cm

Water harvesting structure ----- W-shape micro-catchments(V-shape in 1998/1999)

Trial species; Mangifera indica(5 varieties), Citrus sinensis, Psidium guajava, Wild fruits (5 species)

2) Tending

The following tending techniques were conducted.

Repairing of broken micro-catchment .

Complete weeding (Two times in each rain season.)

Watering is recommended during the dry season. (5 litter/1 week)

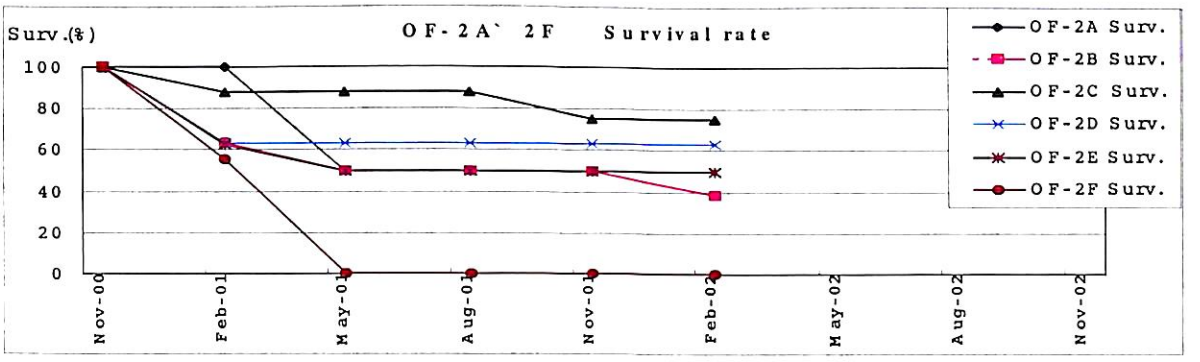
Basically, farmers were supposed to manage the trial plots, but where there was need, the project workers assisted on the management of the site.

Results

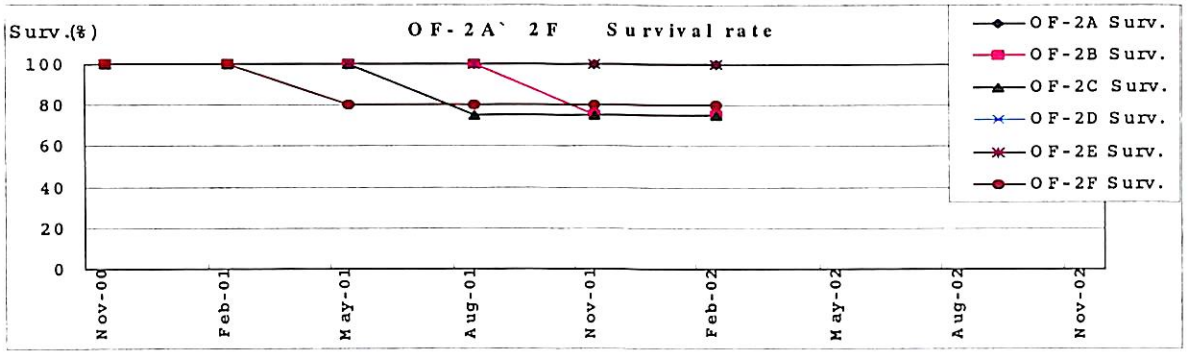
(1) Survival rate

Survival rate of *Mangifera indica* of each trial sites in one year after planting ranged between 0% to 75% (average 41%). Survival rate in two years after planting ranged from 0% to 55% (average 22%). The difference range was very wide and also low. But, where trees were watered (4 to 5 litters/week) during the dry period, the survival rate of the *Mangifera indica* in one year after planting improved up to 62%.

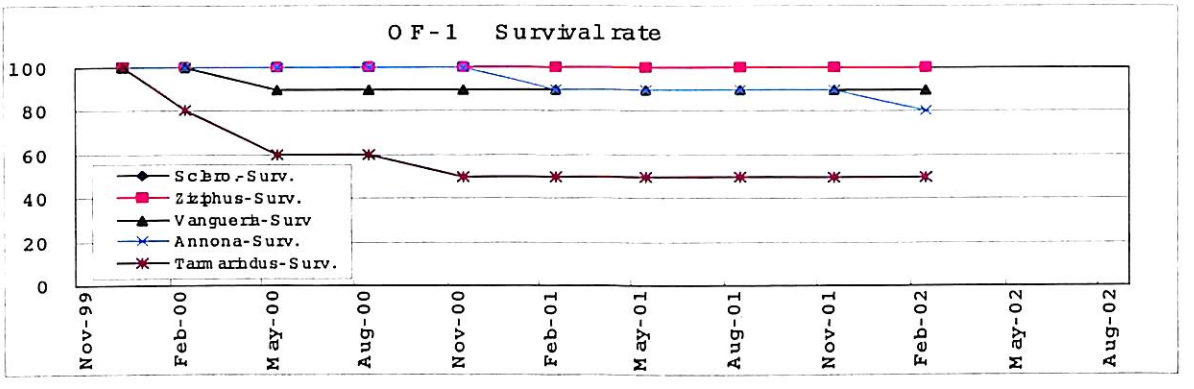
Therefore, the effect of watering was observed.



While the survival rate of *Citrus sinensis,* one year after planting, ranged from 0% to 100% (average 74%). The survival rate in two year after planting, ranged from 0% to 35% (average 35%). The range of survival rate was very wide and in one year after planting, it was relatively high. But, in two year after planting, the survival rate drastically decreased, while where trees were watered the survival rate improved up to 90%. And, therefore, like in the case of *Mangifera indica,* the watering effect was observed.



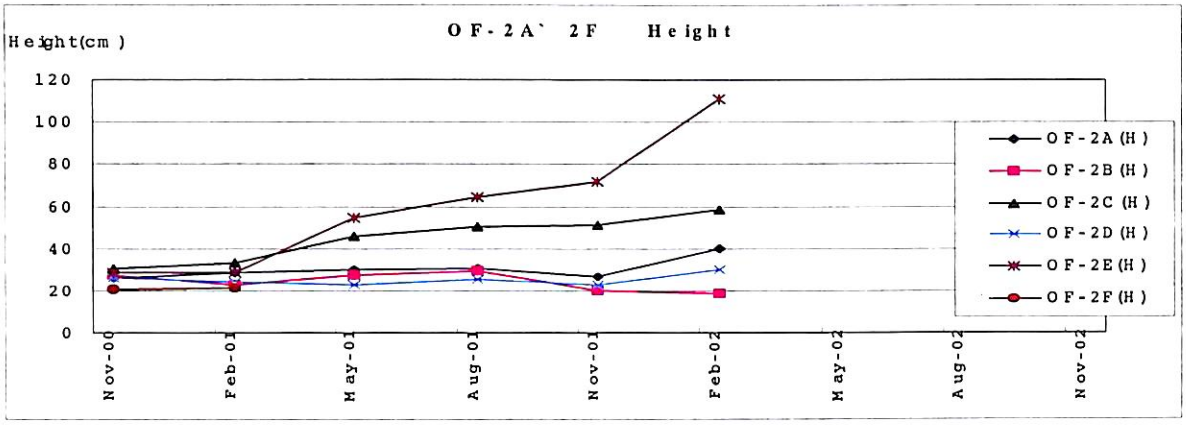
The survival rate of wild fruits in one year after planting showed that, only *Tamarindus indica* was little bit low because other ranged from 90% to 100%. Generally, the survival rate was very good, and this rate did not change much even after two and half.



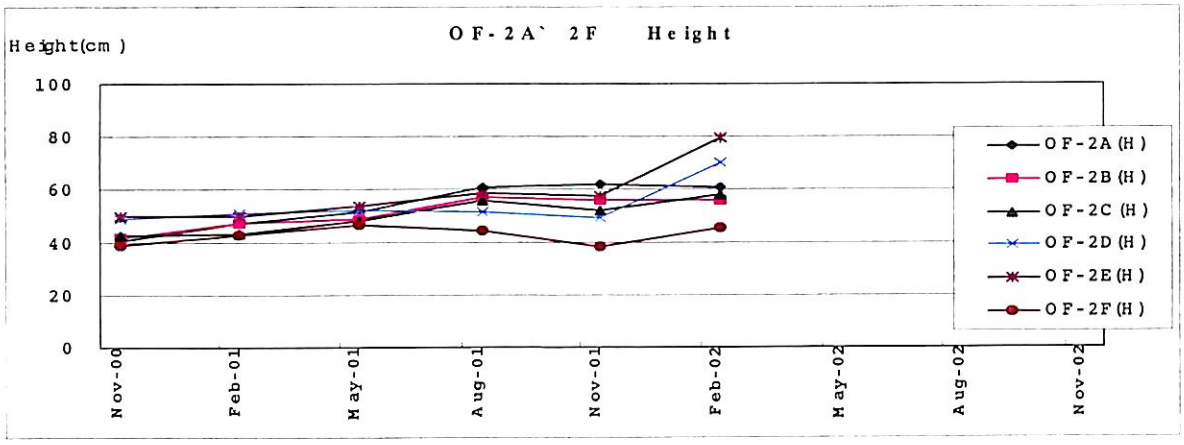
The notable points were wild fruits were also browsed like *Mangifera indica* and *Citrus senensis,* but the mortality was very low, the wild fruits could grow without watering, and in spite of browsing by livestock during the dry period, the rate of mortality remained low.

(2) Growth performance

The height of *Mangifera indica* in each trial site, one year after planting ranged from 10cm to 71cm (average 35cm). In two years after planting, ranged from 22cm to 75cm (average 49cm), like in the case of survival rate, the range of height was very wide and generally, the growth (height) was very low. Where trees were watered, in one year after planting, the growth (height) improved up to 40cm and in two years after planting the trees height improved up to 72cm. The effect of watering could be noticed slightly.



While the height of *Citrus senensis* in one year after planting, ranged from 30cm to 50cm (average 46cm) in two years after planting, the trees height ranged from 40cm to 56cm (average 45cm). Comparing the case of *Mangifera indica,* the range was small and rate of growth was also small. Where trees were watered in one year after planting, the height improved up to 52cm and in two years after planting, the height remained 52cm. The effect of watering could not be seen.

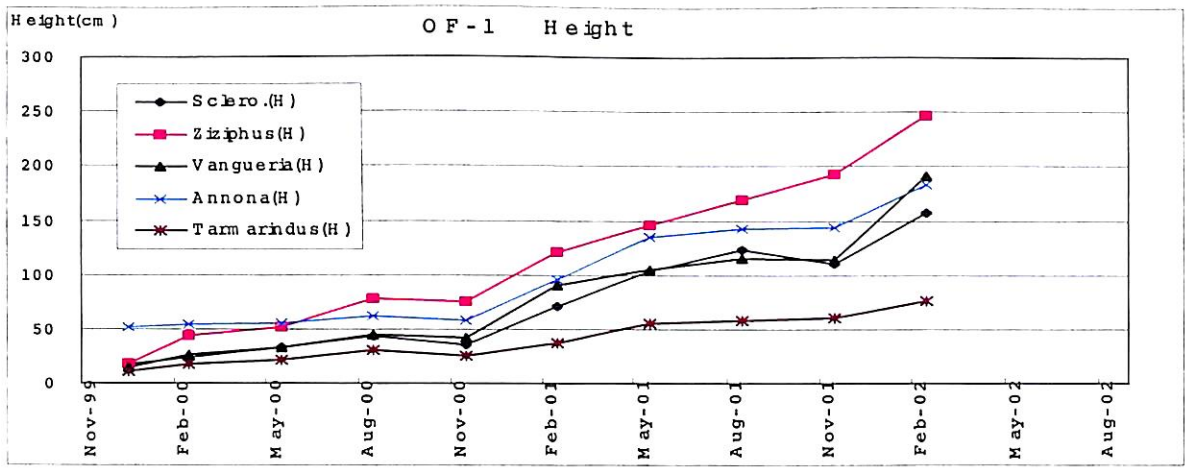


In regard to growth performance, because of limited number of planted trees and including many browsed trees data, the reliability was low, but the following things were observed.

The growth of *Mangifera indica* which were browsed more severely was better than that of *Citrus senensis*..

In the case where trees were watered (4-5 liters/week), the growth of *Mangifera indica* was improved while the growth of *Citrus senensis* remained the same.

The height of wild fruits in one year after planting ranged from 25cm to 75cm (average 47cm). The height of the trees in two year after planting ranged from 61cm to 193cm (average 124cm). Except *Tamarindus indica* whose growth performance was little bit low, the growth of others was impressively high. The notable point was that wild fruits could grow well without watering and could withstand heavy browsing during the dry spell.



(3) Others

Browsing problem by livestock

Most of the fruit trees were severely and severally browsed by livestock (especially goats). Leaves and tip parts of *Mangifera indica* were favored by browsers.

In the case of *Citrus senensis,* the browsing could only be observed on the leaves.

Severely browsed *Mangifera indica* and *Citrus senensis* could not withstand the drought and therefore many died.

Wild fruits and *Psidium guajava* were also browsed but because of their high recovering ability, the mortality rate was very small.

Watering

Farmers were requested to water *Mangifera indica* and *Citrus senensis* but many of them could not follow.

If there is no watering, the trees cannot grow during the dry period and also survival rate drastically go down, in several trial sites, one to two years after planting, all the fruits trees died.

While, on the other hand, where trees were watered (4 to 5 liters/week) *Mangifera indica* showed improved both survival rate and growth performance, the *Citrus senensis* showed some improvement on survival but the growth performance remained almost the same.

Wild fruits could tolerant drought and therefore did not require watering during the dry period.

Among the natural condition, soils, rainfall and physical characteristics of the area are the major factors affecting the fruits planting. Soils in some of the areas are generally poor. Not only are they of low fertility but their physical structure is such that it does not retain or hold enough water for fruits. Supply of supplement water is very important especially during the dry spell. Those farmers who have succeeded in establishing fruits, they have irrigated them during the dry period through bottle watering and flooding together with stone mulching

For those farmers who have not been able to irrigate their trees, water harvesting structures have been put in place to assist in water enhancement.

Most of the convectional fruits species which were distributed to the farmers were all grafted. This was so because the project wanted the farmers to have their own scions near them and at the same time to get more money as they are of high value compared to the local variaties. They also fruit faster than the local ones. Farmers who were not able to irrigate their fruits during the dry period recorded very poor survival rate.

6Discussion

In many trial sites, trees were not watered and the problem of browsing was evident which led to low survival and growth performance. Due to the problem of irregular watering and severe browsing, the collected data was not reliable.

But, through the fruits trees establishment, the following things were observed-

Mangifera indica and *Citrus senensis* required watering (at least 5 liters/week) during the dry period. But *Citrus senensis* was thought to require more water as even after watering the growth performance did not change.

The growth tolerance of wild fruits made them strong and therefore watering was not required during the dry period.

Mangifera indica and *Citrus senensis* were severely browsed by livestock. In some cases, the severely browsed trees died.

Wild fruit were also browsed but recovery rate was high which led to low mortality rate.

Many farmers could not continue to water their fruit trees during the dry period.

In some sandy soil sites, *Mangifera indica* showed better growth even without watering. The reasons which may have contributed to the above, was that

i) In sandy soil, drainage is good and the root growth during the rain season is high.

ii) The top sandy layer act as a mulch which improve water retention in the lower layer of the soil.

The above mechanism require verification in furture.

7Conclusion

Through this fruit trees establishment *Mangifera indica* and *Citrus senensis,* until one or two years after planting watering is essential (at least 5 liters/week) and also prone browsed species require continuous.

So, planting of *Mangifera indica* and *Citrus senensis* can only be recommended to the farmers who can water and protect them fully from the browsers.

While on the other side, wild fruits and guajava, which have ability to withstand dry condition, can be highly recommended to the farmers because they are less labor intensive (no watering and fast recovery).

Generally convectional fruits have done well, where the following factor have been noted.

i) An annual rainfall of at least 750mm is required or irrigation.

ii) Complete weeding should be done whenever weeds are seen.

iii) The soil should be reasonably fertile, with high organic matter. This can be improved by adding manure to the soil.

iv) Fruits require deep and well drained soil. Water logged land is not suitable for fruit growing.

v) Soil should not be too acidic.

Appendix – 1

Progress

Nov. 1998 Experiment plots were established in OF-A,B,C. Mango/Citrus were planted.

Nov.1998May 1999 All farmer (except OF-C) sowed maize between the trees in the both rain seasons. Weeding was conducted on time. Many trees died due to drought in the month of February. Then, farmers were adviced to water.

Jun. 1999Oct. 1999 Many trees were browsed by goats etc. in the dry season on several On-farm sites. The browsing problem occurred almost every year.

Nov. 1999 Experiment plots were established in OF-16. Fruits trees were planted.

Nov. 2000 Experiment plots were established in OF-2A2F. Mango/Citrus were planted.

Mar. 2001 Jul. 2001 6 trial sites were fenced with barbed wire(OF-13,2B,2C,2F).

(Out line of care/ problem)

Trial Site	Weeding/ inter-cropping	Protection/ damage	Others
OF-A	Farmer inter-cropped maize between the trees.	Livestock (goats, cows) browsed trees.	
OF-B	------- ditto --------	------- ditto --------	
OF-C	No inter-cropping. Complete weeding were conducted on time by farmer.	There was no browsing problem.	
OF-1	Farmer inter-cropped maize/ beans/ cowpeas between the trees.	Livestock (goats) browsed trees.	Watering conducted. (2 liter2 times / week)
OF-2	------- ditto --------	Livestock (goats) browsed some trees.	------- ditto --------
OF-3	------- ditto --------	------- ditto --------	
OF-4	------- ditto --------	Livestock (goats, cows) browsed some trees.	
OF-5	------- ditto --------	------- ditto --------	
OF-6	------- ditto --------	------- ditto --------	
OF-2A	------- ditto --------	------- ditto --------	Watering conducted. (2 liter2 times / week)
OF-2B	------- ditto --------	------- ditto --------	------- ditto --------
OF-2C	------- ditto --------	------- ditto --------	------- ditto --------
OF-2D	------- ditto --------	------- ditto --------	------- ditto --------
OF-2E	------- ditto --------	There was no browsing problem.	------- ditto --------
OF-2F	Farmer inter-cropped maize between the trees.	Livestock (goats, cows) browsed some trees.	

Fodder establishment

1 Introduction

In the ASALs, during the dry season, shortage of fodder causes a lot of social problem. And so, fodder trees which can produce animal foliage (feed) during that time play a very important role. To identify suitable fodder trees species in Kitui, several useful fodder tree species were introduced.

Objective; To test and identify suitable tree species for on-farm fodder production in project operation area..

2Site description

Five fodder tree species, namely, *Prosopis Juliflora* (OF-1), *Prospis pallida* (OF-1,2,3), *Melia volkensii* (OF-1,2), *Leuceana leucocephala* (OF-1,2,3), *Calliandra calothyrsus* (OF-3) were eatablished in 1999 in Central, Kabati and Chuluni division as shown below.

(Farmer's name & location)

Trial Site	Farmer's name	Location	Year Established
OF-1	Mr. Justus Makanda	Maliku / Central Div.	1999
OF-2	Mr. George Mwaniki	Kathivo / Kabati Div.	1999
OF-3	Mr. Jackson Mutua	Nzambani / Chuluni Div.	1999

(Site description)

Trial Site	Area(ha)	Eco-Zone	Slop (Terrace)	Soil	Rainfall (mm)	Pre-site condition
OF-1	0.41	-2	1° (none)	Luvisols PH 5.7-8.1 Effective depth 110cm Soil texture SL	Oct.1999542 Oct.2000610	Grazing land
OF-2	0.13	-2	5° (none)	Luvisols PH 6.3-7.1 Effective depth 73cm Soil texture SCL	Oct.1999567 Oct.2000518	Grazing land / Farm land
OF-3	0.09	-2	5° (none)	Cambisols PH 6.9-9.5 Effective depth 125cm Soil texture SL	Oct.1999646 Oct.2000734	Farm land

3 Method

(1) Design/Treatment

In three on-farm trial sites, five different fodder tree species were established.

Survival rate and growth (height and root collar diameter) were assessed every three months and monitoring was conducted every month to confirm the each fodder trees growth performance.

(2) Planting and tending techniques

1) Planting (including site preparation)

Site preparation ----- oxen-plough

Spacing ----- 3.5m x 3.5m (In the case of OF-3, 1m spacing line planting)

Hole size 45cm x 45cm

Water harvesting structure ----- W-shape micro-catchments (V-shape in 1998/1999)

2) Tending

The following tending techniques were conducted.

Repair of broken micro-catchment.

Complete weeding (Two times in each rain season.)

Basically, farmers were supposed to manage the trial plots, but where there was need, the project workers assisted on the management of the sites.

Results

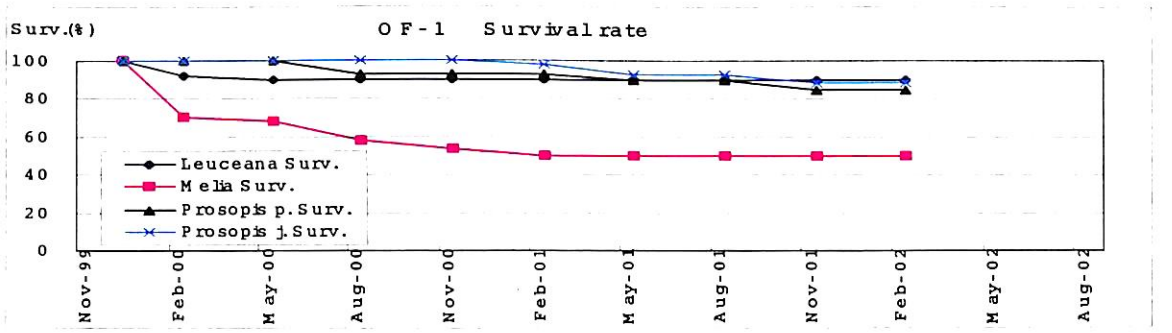
(1) Survival rate

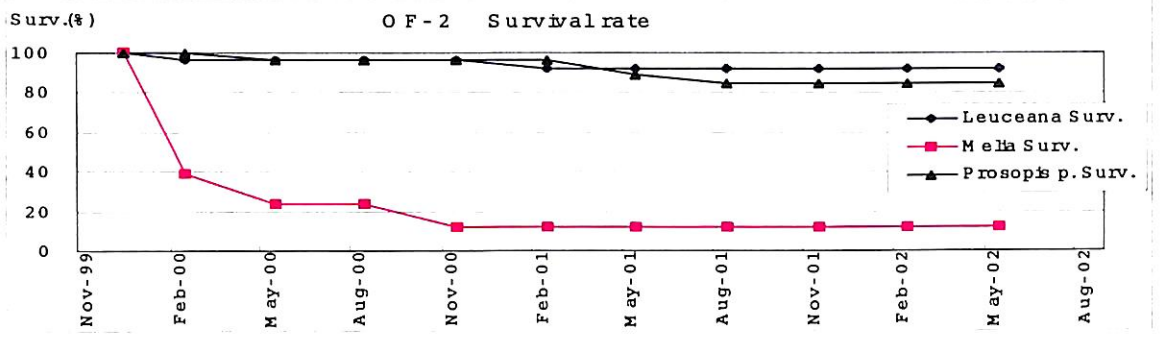
The survival rate in one year after planting, of *Prosopis pallida*, *Prosopis juliflora* and *Leuceana leucocephala* ranged from 80% to 100%, and there was no difference between different species on survival rate.

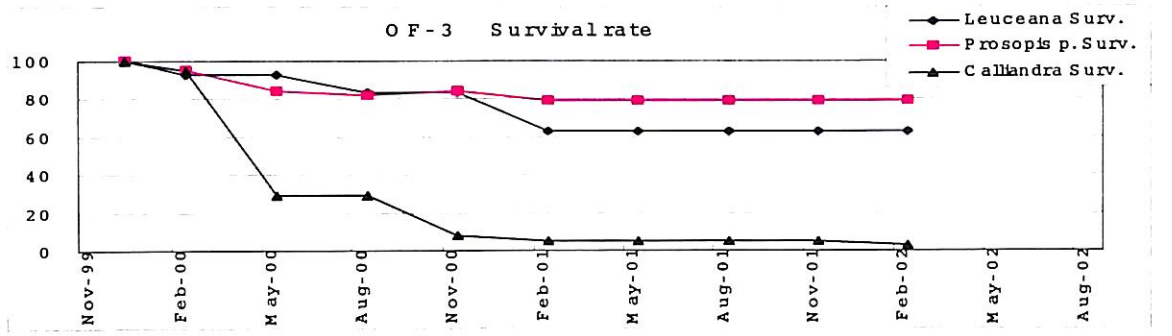
Although trees were browsed in all the trial sites, the mortalities were very minimal.

The survival rate of *Melia volkensii,* in one year after planting in OF-1 was 50%, OF-2 was 10% (it was very low). And also the survival rate of *Calliandra calothyrsus* in one year after planting in OF-3 was 5%.

The suggested reason for mortalities for *Melia volkensii* were water logging at the time of planting and physical damage during ploughing. In the case of *Calliandra calothyrsus,* it was mostly due to drought.







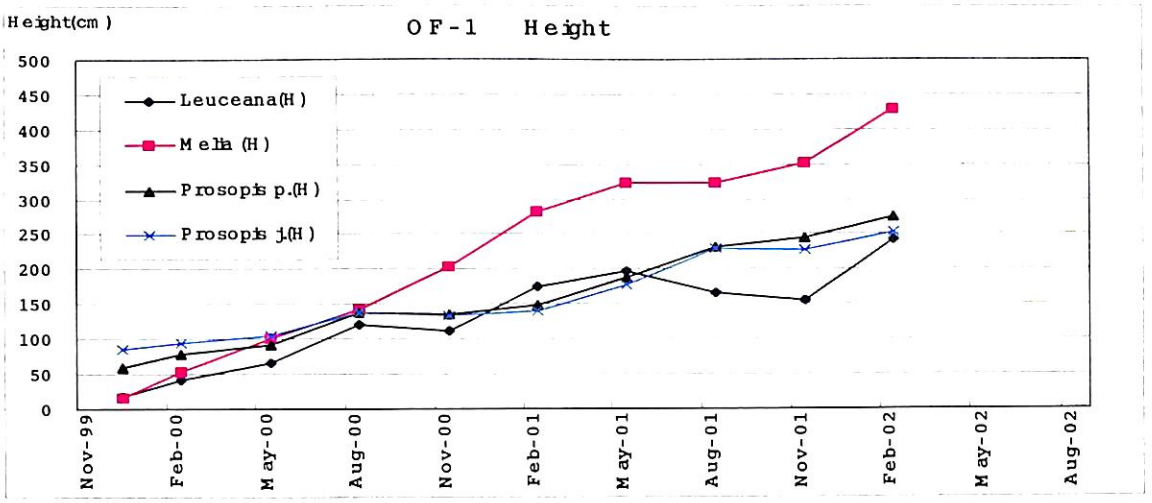
(2) Growth performance

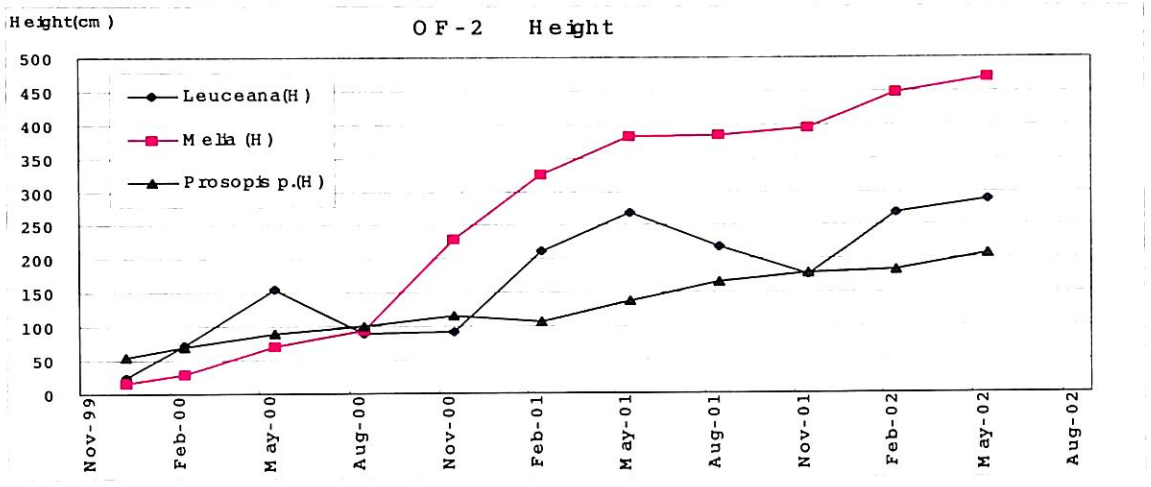
Comparing the growth performance between each fodder species in one year after planting, *Melia volkensii* performed better (2m to 2.5m) followed by *Prosopis pallida*, *Prosopis juliflora, Leuceana leucocephala,* and *Calliandra calothyrsus*, which ranged from 0.5m to 1.5m.

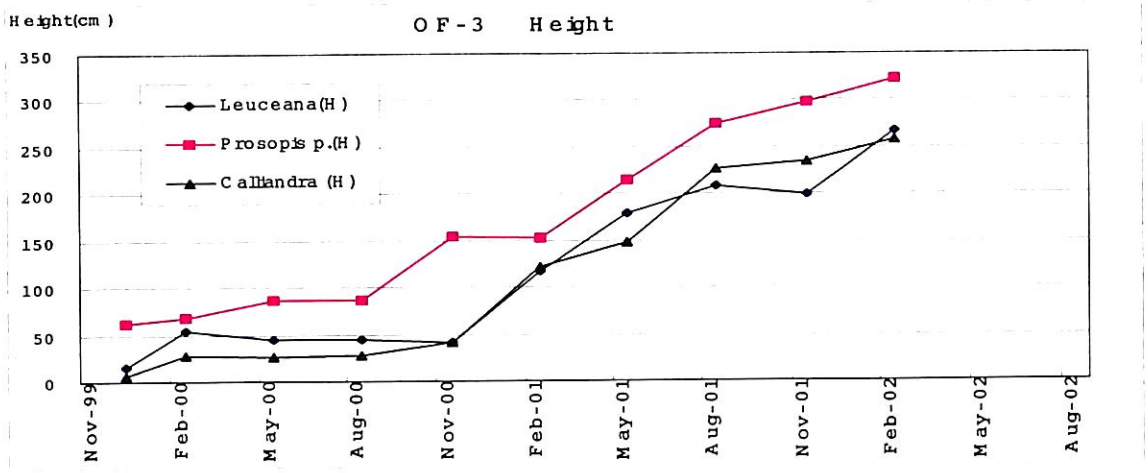
The growth performance of fodder tree species from each trial site, the range was quite wide due to effect of repeated browsing. In OF-3, where trees were severely browsed, the growth was very low, and also, where trees were frequently browsed, the growth of those trees remained low.

In addition, it was confirmed that, *Leuceana leucocephala* which has high nutritional value to the livestock can be harvested within the first year.

Only Leuceana leucocephala has been utilized or harvested because other species are surposed to produce pods or fruits which require more time. There has been problem of browsing by goats and wild animal in all the plots planted with Leuceana leucocephala. Biomass assessment on Leuceana leucocephala trees has been carried out. This was implemented to relate the size of tree and biomass it can produce.







Discussion

From the trial sites, the following things were observed.

Prosopis pallida, *Prosopis juliflora* and *Leuceana leucocephala* showed some resistance to drought and recovering ability after heavy browsing.

The growth performance of *Leuceana leucocephala* in the initial stage (one year or so) was very

impressive. During the first dry period after planting, the first harvesting was conducted. And also, at the time of harvesting, one meter harvesting height was used to reduce the browsing problem from goats and wild animals (e.s. dik dik). Also it was noted that even after using high cutting height (1m), the coppicing was good and this height can be recommended to the farmers.

Generally, *Calliandra calothyrsus* is known to do well in humid areas and from this trial it was confirmed that it is not suitable in dry area.

It was confirmed that mortality of *Melia volkensii* due to water logging during the establishment stage was big and the growth performance especially in the initial stage was very high. For the species which produce fruits (pods) for fodder require longer period (between 3 to 5 years).

In the tree trial sites where fodder trees were introduced, farmers intercropped and they continued to harvest good yields even after two and half years after planting. In the case of *Leuceana leucocephala* which can be harvested every dry period, unless competing crop is introduced, intercropping can be carried out for a long time.

Conclusion

Through this fodder establishment, some fodder tree species can be planted in semi arid area of Kitui, especially, *Leuceana leucocephala* which has good growth and coppicing ability. Also the good coppicing ability can an able farmers do intercropping, which maximizes productivity of the unit land.

Appendix – 1

Progress

Nov. 1999 Experiment plots were established in OF-1,2,3. Fodder trees were planted.

Nov. 1999May 2000 Farmer intercropped maize/ beans/ etc. between the trees in the both rain seasons. Farmer/ Project worker conducted complete weeding.

Jun. 2000Oct. 2000 Many trees were browsed by goats/etc., in OF-1,2. And, almost all Calliandra calothyrsus died due to drought in OF-3.

Nov. 2000May 2001 Farmer intercropped maize/ beans/ etc. between the trees in the both rain seasons. Farmer/ Project worker conducted complete weeding.

Mar. 2001Jul.2001 The 3 trial sites were fenced with barbed wire (OF-13)

(Out line of care/ problem)

Trial Site	Weeding/ inter-cropping	Protection/ damage	Others
OF-1	Farmer inter-cropped maize/ beans/ cowpeas in both rain season. Farmer conducted complete weeding in both rain season.	Dik-Dik, goats and cows browsed some trees in the dry season. Some trees got damaged by Oxen-plough.	Many M. volkensii died due to water logging during the first long rain season. Many micro-catchments were browken at the time of Oxen-plough and complete weeding.
OF-2	Farmer inter-cropped maize/ beans in both rain season. Farmer conducted complete weeding in both rain season.	Some trees got damaged by Oxen-plough.	Many M. volkensii died due to water logging during the first long rain season. Many micro-catchments were browken at the time of Oxen-plough and complete weeding.
OF-3	Farmer inter-cropped maize and etc. in both rain seasons. Farmer didn't conducted complete weeding.	Livestock (mainly goats) browsed trees in the dry season.	Many micro-catchments were browken at the time of Oxen-plough and complete weeding.

Nursery Experiment X

Seeds germination

Introduction

The germination of seeds of Melia volkensii and Terminalia brownii are very poor. Although both of them are very important species for farmers. Both species are commonly found in ASALs and play important roles to the communities living within those areas. Major uses of these species include-

(a) Melia volkensii

Farmers grow or leave this tree in their land primarily because of its high quality and close-grained timber, both leaves and fruits are valuable dry season fodder for livestock, it is also the principal species used to make log hives because, the wood is easily worked and shaped. The flowers provide excellent bee forage, branches lopped during routine management(Pruning) are used as fuel wood. It also has some medicinal properties.

(b) Terminalia brownii

Terminalia brownii has been growing naturally in ASALs until recently when the efforts of planting and conservation of existing ones were put in place. The reason was that this species is also becoming endangered because it is being over exploited by woodcarvers and other users who make farm implements and medicinal materials.

Broad Objective; To develop simple and effective methods of propagation that are appropriate for farmers.

Specific Objectives;

1) Determine appropriate and effective method of germinating M. volkensii and T. brownii from seeds.

2) Determine alternative methods of propagating M. volkensii.

Materials and methods

1) Determine appropriate and effective method of germinating M. volkensii and T. brownii from seeds.

(a) Different treatments were tested in order to improve the germination capacities of these two species.

Treatment	
Melia volkensii	Terminalia brownii
Seed extraction	Dewinging
Nipping	Nipping
Soaking in cold water	Soaking in cold water
Slitting	
Combination	
Control	

Germination trials were conducted in sterilized sand at Tiva nursery. Each treatment had 100 seeds in three replicates.

(b) Germination trial for different provenances

Treatments	
Melia volkensii	Terminalia brownii
Kavisuni	Kitui
Yatta	Homabay
Nuu	

Germination trials were conducted in sterilized sand at Tiva nursery. Each treatment had 100 seeds in three replicates.

2. Determining alternative methods of propagating M.volkensii

Two types of vegetative materials were used.

Stem cuttings

Root cuttings

IBA 0.5% rooting hormone was used.

The experiment was conducted in a non-mist(poly) propagator at Tiva nursery. Each treatment had 30 cuttings in three replicates

Result

1. Determining appropriate and effective methods of germinating M. volkensii and T. brownii from seeds.

(a) The results indicated that Melia volkensii and Terminalia brownii seeds require a combination of treatments to give good germination.

Melia volkensii

Treatment	Germination %
Extraction + Nipping	11%
Extraction + Nipping + soaking	37%
Extraction + Nipping + soaking + Slitting	79%
Extraction only	0%

Terminalia brownii (Homabay provenance)

Treatment	Germination %
No treatment	2%
Dewinging + soaking	14%
Dewinging + Nipping + soaking	54%

(b) Result on provenance trial showed that certain provenances are superior than other on germination performance. About M.volkensii, Kavisuni gave higher germination rate than Yatta and Nuu while Terminalia brownii from Homabay gave better germination rate than Kitui provenance. It was also observed that Terminalia brownii seeds collected from Kitui are infected by seed borers.

Germination of Melia volkensii seeds from different sources

Provenance	Germination %
Yatta – Kitui District	55%
Nuu – Mwingi District	74%
Kavisuni – Kitui District	80%

Germination of Terminalia brownii seeds from different sources

Provenance	Germination %
Kitui	1%
Homabay	54%

2. Determining alternative method of propagating M.volkensii

The results from this study indicated that use of root cuttings could be an alternative method of propagating Melia volkensii. The results also indicated that use of rooting hormones is beneficial in propagating of Melia volkensii, through cuttings. It is also important to note that even without using hormones, it is possible for farmers to use root cuttings. Stem cuttings sprouted but never rooted with or without the rooting hormones.

Propagation of Melia volkensii by cuttings

Cuttings	Germination %
Root cutting	9.6%
Stem cutting	0%

Discussion

The results of this study showed that, M.volkensii could be propagated through two ways, root cuttings and seeds. On T.brownii, provenance was more sensitive to germination than treatment. The low germination rate got from Kitui provenance may have been attributed by the fact that, most of the seeds collected from Kitui were infected by seed borers.

Conclusions

Melia volkensii require simple and more suitable propagation method which can be used by a range of users, farmers being one of them. Some of the tested techniques have shown improved

germination rates but high skills and tools used to extract seeds from the nuts are not friendly to farmers who should be the major beneficiaries. On T.brownii it may be more advisable to establish seed stand of Homabay provenance for future collection.

Termite Control Experiment

Introduction

Termite is one of the main cause of poor tree establishment in dry areas. Termites cause damage to both seedlings in the nursery and trees in the field. Main species which are more susceptible to termites included; Eucalyptus species, Grevillia species, Casuarina species, Leuceana species etc. Termite attack is mostly evident during the dry period when the trees are stressed. Farmers have several ways of controlling termites in their farms depending on ones knowledge and financial status. Some use convectional (Commercial Chemicals) method while others use concoctions. Convectional method is more effective than concoction because they can instantly kill the termites while the most concoction can only repel. There are advantages and disadvantages of using both termite control methods.

(1) Advantages and disadvantages of convectional methods.

) Advantages of convectional methods.

Improve survival rate of the target species.

Farmer able to get benefits from the planted trees.

)Disadvantages of convectional method.

Poisonous and if not carefully handled, can lead to death.

Not environmentally friendly, pollute water, soil and air.

Expensive and therefore can only be used by well off farmer.

(2) Advantages and disadvantages of concoction method.

) Advantages of c concoction method.

Easily available to the most farmers.

It is affordable.

)Disadvantages of concoction methods.

Can not kill the already attacking termites.

Survival rate may be lower as compared to convectional method and thus lead to less benefit of trees products to the farmers.

Objective; To determine effectiveness of different local material for controlling termite damage

on susceptible tree species.

Materials and methods

The experiment was conducted in Pilot forest area at Tiva Kitui District in Nov. 1999. The area receives amean annual rainfall between 400mm- 800mm and has an average temperature of 28.

Plant materials

Seeds for this experiment were collected within Kitui district. The seedlings were raised in Tiva nursery. All the sowing, tending and watering regimes followed the normal procedure used in the nursery.

Experimental design

The experiment was a complete randomized block design with various termites control concoction being the treatments. Three replicates were included and each treatment consisted of 8 plants.

Treatment

Neem cake
Tobacco powder
Chilli + Omo + Tabacco
Control

Species Grevillia robusta

Parameters

Take survival count every 3 months
Height and Diameter measurements every 3 months

Result

The results of this study indicated that there was no significant difference between the different concoctions used on survival. May be due to lack of information about the residue effect of the concoctions may have affected the results because time of reapplication may be prolonged also there is an aspect of leaching during the rains and also damage by livestock which browsed severely the planted trees.

Survival rate (%)

Treatments	After 6 months	After 10 months	After 15 months	After 18 months	After 21 months
Neem cake	63%	58%	38%	29%	25%
Tobacco powder	88%	87%	31%	21%	21%
Chilli+Omo+Tobacco	67%	67%	38%	38%	29%
Control	54%	54%	50%	29%	21%

Discussion

The data collected from the experiment may not be adequate to make any conclusive report because there was problem of livestock which interfered with both survival performance and growth. Also dosage and time of reapplication is not known. This may also affect the effectiveness of the concoctions.

Conclusion

Use of concoction may be cheap and convenient to the farmers if only the right type and application methods are fully confirmed. Use of ineffective concoction may lead to serious frustrations to the farmers if they are used and thus lead to poor planting of the trees especially within ASALs.

3rd Draft

A draft of the SOFEM extension activity

Seed handling, Tree establishment and Management Guideline for ASALs (Kitui experience)

by

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Technical guide for division forest extension officers (DFEO)

1 Preface

Good plant quality is the basis for tree planting success. A good quality tree will enable a farmer to harvest wood or other products sooner by increasing the returns on the farmers investment. A good tree can only be produced from a high quality seed since the characteristics of the parent trees greatly influence the characteristics of the seedlings.
High quality seeds are got from good mother trees characterized by big size, straight stems and fast growth. Only mature seeds should be collected from such trees. The collected seeds should be cleaned. The clean undamaged seeds should be stored in a cool dry place away from sunlight.

To establish good and successful On-farm woodlot (farm forest) in dry areas of Kitui, it is important to select good and suitable species depending on the intended end use and site characteristics. The site for woodlot establishment should be cleared of all existing vegetation in order to avoid competition for moisture and nutrients. Water harvesting techniques should be used to fully utilize the scarce rainwater by improving water infiltration into the soil. Site management, especially, weeding should be done on time. These silvicultural operations namely site clearing, water harvesting and weeding ensure that the planted trees utilize more efficiently the limited moisture and the scarce nutrients in the soil.

Interest in dryland afforestation is increasing rapidly, and many players are coming into the scene implementing major projects. Silvicultural practices for dryland wood lot development are still under different stages of development and experimentations. The Kenya Forest Research Institute (KEFRI), Forest Department (FD) and Japan International Cooperation Agency (JICA) have tried several silvicaltural practices both on - station and on - farm for the last sixteen years in Kitui district, through Social Forestry Extension Model Development Project (SOFEM) and Social Forestry Training Project (SFTP). These experiences have been consolidated in this guideline to assist in successful establishment of wood lots (farm forest) in the drylands of Kenya.

This guideline highlights the basic silvicultural practices in seed handling, seedling production, tree planting and tending techniques used

in semi arid areas of Kitui district. It is written for middle technical cadre, drawing on experience from both SFTP and SOFEM Projects.

2 Seed

2-1 Seed collection

Seeds should be collected from a mature good mother tree e.g. big, straight, fast growing if timber is the desired product. Only mature and fresh seeds should be collected as immature ones have low viability and short life. Seed can be collected directly from trees by picking fruit or collected from under neath the trees. Because of variation between trees in seed maturation, seed harvested from different mother trees should be mixed before being used. In case, seeds from other source are to be used find out origin, because wood lots should be established from materials which has an identified source. Use seeds from an area as similar as possible to the area where you are intending to plant the raised seedling.

2-2 Seed pre-treatment and seed storage

If seeds are enclosed in a fleshy fruit, remove the flesh with a knife, wash off the rest under water, and sow the seeds immediately.
For seeds in a seed pod, such as a *Leuceana leucocephala*, let the pods split open naturally by laying them in a semi-shade place.
Similarly, for other fruits with a hard coat, drying them in semi-shade or gentle cracking should open them.
Collected seeds should be dried well, sieved to remove broken and infected seeds. The dried seeds should be stored in dry and cool place in air tight containers such as plastic or glass bottles with screw tight lids. The length of time seed can be stored varies greatly between species.

3 Seedling

3-1 Size of Seedlings

Quality tree seedlings should be healthy, strong, sturdy and about 30cm tall before planting. As a general rule, quality seedlings

should have small medium shoot systems and a large root systems, ie a balance between shoots and root mass. Unbalanced seedlings have too many leaves and too few roots.

3-2 Hardening-up

Seedlings which are used to establish farm forest should be hardened up so that they can withstand harsh environmental conditions in the field particularly the absence or irregular water supply. This hardening is achieved by exposure to full sunlight and a gradual reduction of watering frequency starting one month before out-planting.

3-3 Seedling production

When raising seedlings, economic aspect should be considered before deciding on the species to be raised. The seedling requirements should guide the number of seedlings produced to avoid left over that are expensive to maintain in the nursery.

4 Selection of planting site

If one wishes to establish a woodlot on his/her farm, agricultural practices should be adjusted to accommodate tree planting to avoid any major operation problems in the long term.
Valuable indigenous tree species for example *Melia volkensii* should be left during clearing of vegetation on the sites intended for planting.

The maximum single area to be cleared for woodlot establishment should not exceed 2 ha if possible they should be in even smaller scattered plantings. Strips of between 20m and 50m should be left to protect the land against degradation through soil erosion.

The slope of the planting site should not exceed 5% unless constructions of soil erosion control structures such as terraces are in place. If the site has over 5% slope and there is no soil erosion control structure, it is important to maintain the existing valuable indigenous tree species in the area. In case of a site with a high density of valuable indigenous tree species, conservation and management of the forest should be encouraged rather than planting.

5 Selection of tree species

When planting farm forests there are several aspects that should be considered such as economic aspect, purpose, drought tolerance, termites resistance and growth performance. That is, the selected tree species should meet the purpose for which it is planted, grow fast enough to fulfill the purpose, produce goods with ready market and be able to withstand the drought and termites infestation. The following tree species are recommended for planting in Kitui district.

Timber/carving- *Melia volkensii* (Mukau), *Azadirachta indica* (Neem), *Dalbergia melanoxylon* (Mpingo), *Terminalia brownii*. *Grevillea robusta* (Mukima) and *Eucalyptus camaldulensis* are recommended only in areas which have less problem of termites.

Fuel wood- *Senna siamea, Acacia species.*

Fodder- *Melia volkensii, Leuceana leucocephala, Prosopis juliflora, Acacia tortilis, Acacia mellifera.*

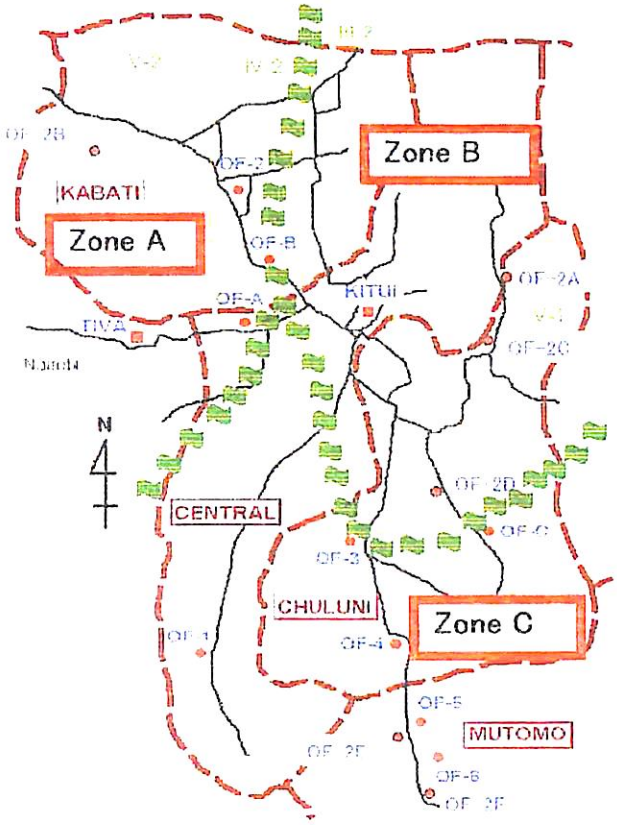
Fruit- *Carica papaya* (paw paw), *Psidium guajava, Sclerocarya birrea, Ziziphus mauritiana* and *Annona senegalensis*. *Mangifera indica* (Mangoes) and *Citrus sinensis* (Oranges) are recommended for areas where watering can be done especially during dry periods.

The tree species listed above have been tried in different areas(zones) with different climatic, physical conditions and population densities which generally influence purpose for tree planting within the communities. On the basis of these trials, recommended tree species for different zones are given below.

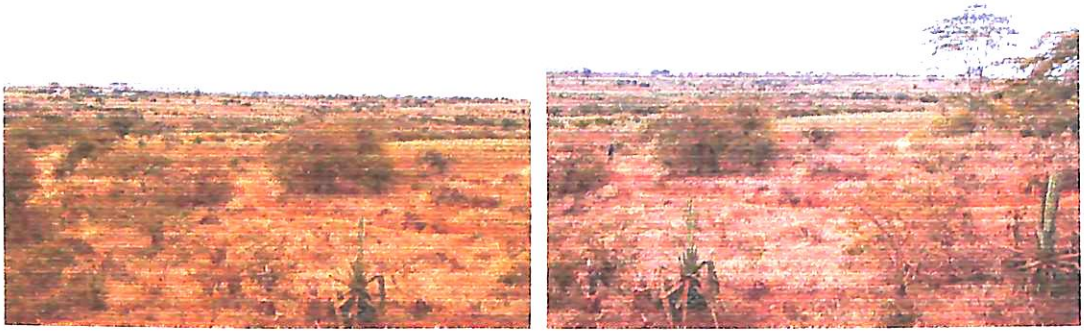
Zone A.

This zone is characterized by low annual rainfall (400mm～600mm), poor soils, high incidences of termite infestation and low vegetation cover. It lies within agro-ecological zone, IV - 2 — V - 2. This covers lower Kabati area(Fig. 1). The recommended tree species include:-

Fig. – 1



I . Fuelwood	*-Senna siamea, Acacia tortilis, Acacia senegal, Acacia mellifera, Acacia nilotica, Acacia seyal and Balanite aegyptica*
II . Fodder trees	*-Leuceana leucocephala, M. volkensii, B. Balanite Acacia tortilis, Acacia senegal, Acacia mellifera, Acacia nilotica, Acacia seyal and aegyptica*
III. Timber trees	*-Melia volkensii*
IV. Fruit	*-Carica papaya, Psidium guajava, Mangifera indica*
V . Other use (medicinal etc.)	*-Azadirachta indica*



Dry and low natural vegetation covers typical site in Zone A.

Zone B.

This covers some parts of Central division, upper areas of Kabati and northern Chuluni division. Main characteristics of these areas include:- more humid, less problem of termites, high vegetation cover and small land holding size. It falls within agro-ecological zone, III - 2 and V - 1. The recommended tree species include:-

I . Fuelwood	-*Senna siamea, Grevillea robusta, Eucalyptus camaldulensis, Eucalyptus tereticornis, Azadirachta indica*
II . Fodder trees	-*Leuceana leucocephala, Melia volkensii, Acacia tortilis, Acacia senegal, Acacia mellifera, Acacia nilotica, Acacia seyal*
III. Timber trees	-*Grevillea robusta, Melia volkensii Eucalyptus camaldulensis, Eucalyptus tereticornis,*
IV. Fruit	-*Carica papaya, Mangifera indica, Annona senegalesis, Citrus sp.*

Humid with man-made forest consisting of exotic species covers typical site in Zone B.

Zone C.

This region covers lower part of Central division, lower parts of Chuluni and upper side of Mutomo division. The zone is dry, has high termite prevalence, abundant natural vegetation and big land holding size. The zone falls under agro-ecological zone, V - 1 and V - 2. The recommended tree species include:-

I . Fuelwood	-*Senna siamea, Acacia tortilis, Acacia senegal, Acacia mellifera,Acacia nilotica, Acacia seyal*

II. Fodder trees -*Melia volkensii, Leuceana leucocephala, B. aegyptica Acacia tortilis, Acacia senegal, Acacia mellifera, Acacia nilotica, Acacia seyal*

III. Timber trees -*Melia volkensii, Azadirachta indica, Dalbergia melanoxylon and Terminalia brownii.*

IV. Fruit -*Carica papaya, Mangifera indica, Psidium guajava*

The list of recommended species is not exhaustive as screening of more species with potential for dryland is on-going.

Low rainfall, but abundant natural vegetation covers typical site in Zone C.

6 Site preparation for tree planting

The effect of ground preparation on tree establishment and growth can be very marked and last throughout the life of the crop. Site treatments that ensure high survival and rapid early growth are essential in tree establishment in semi arid conditions. The most important site preparation operations are discussed below.

6-1 Bush clearing

In dry areas, removal of existing vegetation is very important to avoid competition for moisture, nutrient and maximize utilization of the limited moisture in the soil.

There are several ways of removing the vegetation from tree planting sites. These include, debarking and uprooting of the big trees. The perennial grasses should be removed completely. The rhizomes and roots that may sprout later should be removed. The cleared bushes and grasses should be used as compost, dead fencing materials or burned to reduce the seeds of the weeds in the planting

site.

Bush clearing and burning of the planting site.

6-2 Site preparation

Compacted soil is not good for tree growth as it may cause, poor root development of planted seedlings. It may also cause poor infiltration of rain water leading to retarded growth of the trees and excessive runoff. Therefore, the planting site should be ploughed or tilled to improve water infiltration, root development and aeration. All land preparation, i.e. ploughing/tilling, should be done along the contour to avoid soil erosion.

Moisture enhancement through oxen-ploughing and hand tilling.

6-3 Hole size

Use of big holes may be of advantage to the planted seedlings in the initial stages. But the effect disappears as years go by. In specific cases, sizes of the hole would depend on the site condition and seedling container size. A hole size of 30cm by 30cm is adequate.

Where hard surface exist (murram) use of big holes is recommended to improve the water infiltration.

30cm x 30cm hole is adequate.

6-4 Water harvesting structures

In the dry areas, it is important to harvest limited run offs for tree use. Therefore, construction of water harvesting structures is important as they enhance water infiltration. The water harvesting structures may also protect soil from water erosion.
There are several types of micro catchments which can be used, depending on site condition. However, where site is flat or terraces exist, use of micro catchment may not be necessary.
The typical water harvesting structures used in Kitui district are discussed below.

6-4-1 V-shaped

To collect run off to the planted hole, V-shaped basin is constructed with embankments measuring 20cm – 30 cm in height.
The size of the micro catchment depends on soil type, rainfall amount, and the slope of the area. Generally, the lower the rainfall, the bigger the structured required.

V-shaped micro-catchment structure.

6-4-2 W-shaped

This type of micro catchment is constructed by connecting V-shaped catchments. W-shaped micro catchment is very effective as it can collect a lot of run off within the catchment area. However, this type of micro-catchment has one major weakness in that, if constructed on sloppy area, it can easily break all the run off is collected. Generally, W-shaped is easily broken by run off than V-shaped and requires bigger banks.

W-shaped micro-catchment structure.

6-4-3 Contour trench

This structure is made by constructing trenches. The size of the trench depends on slope of the area. The depth range between

30－45cm and distance from one trench to the other range from 10m to 15m. Run off water is collected in the trench and thus improve infiltration. Contour trench is stronger, more effective and easier to maintain than W-shaped and V-shaped catchments.

7 Planting methods

7-1 Planting season

Planting of trees should start when the rainfall amount has accumulated to about 100mm or when the soil particles form a muddy wet bond. Generally, tree planting time in Kitui starts from 1st Nov. to late November.

Actual tree planting in on-farm trial sites.

7-2 Tree planting

Spacing depend on purpose.

① Wood lot 4m x 4m
② Hedge (line) 2m

7-3 Gaping or Beating up (replanting dead trees)

Two weeks after planting, it is important to do survival count. In case some seedlings have died the dead seedlings should be replaced as soon as possible.

8 Site and tree management

8-1 Weeding

Weeding is an act of removing unwanted vegetation which compete with the desired plants for moisture and nutrients. In regions that suffer prolonged drought, weed control is critical for survival and growth of the young trees.

8-1-1 Weeding method

Weeding should be done by use of oxen－plough or by hand tilling. In principle, all the planted sites should be weeded. In case the planted trees are still small or the spacing is wide, spot weeding is accepted to save time and labor. In such situations, the spot weeded area should be two times the height of the tree.
Use of high valuable tree species (e.g. fruits, Melia volkensii) or intercrop which provide immediate benefits to the farmer makes him invest valuable labor in complete weeding of the trees.

Influence of different weeding techniques (complete and spot weeding) on tree growth.

8-1-2 Weeding duration

After planting, weeding should be done immediately the weeds emerge. Weeding should be done two or three times in one rain season.

8-2 Pruning

Pruning is used primarily to produce knot－free high quality

timber. On the other hand, in intercropping systems, pruning is done to reduce the lateral growth of branches, which compete with crops for sunlight.
Pruning should be done by using pruning tools such as pruning saw or secateurs. Pruning to 2/3 of the tree height is recommended if timber is the desired tree product. For fodder or fire wood production, pruning is not recommended.

Pruning should start once planted trees attain a height of 1m and this should continue until the desired end product is attained.
In principle, pruning should be done towards the end of dry period. For fast growing species such as *Melia volkensii*, it should be done twice annually during the first few years. Where branching is fast, frequent pruning may be required (3 to 4 times).

Unpruned and pruned *Melia volkensii*, trees in one of the on-farm trial site.

8-3 Thinning

Thinning is designed to remove weak or poorly formed trees and shoots, to give fewer remaining trees more resources to grow.
Thinning of wood lots is sometimes used to generate interim income (sale of poles), while the remaining trees go on to a longer period to give more products such as timber. In Kenya, plantation designed to produce sawn timber have initial stem densities of between 1,300 and 3,000 stem/ha depending on the climate (Lower densities in the drier climates). Eventually these densities are reduced to about 250 · 300 stems/ha.
In the case of timber production, 3−4 times may be required. The time of thinning should be determined by growth of the trees. Thinning should be done at the end of dry season. The rate of thinning should range between 30−50%.

8-4 Coppicing

Coppicing is vegetative regrowth from stumps of tree trunks that have been cut back to near ground level.
Main reason for coppicing is that it saves the act of planting new trees after harvesting. In principle, the coppicing height should range between 20cm－30cm. Cutting should be slanting. Once coppices have attained 1m heights, selection of stems to be retained should be done. At least, 2 to 3 stems should be left depending on end desired product. In case of fodder, cutting height should be 1.0m－1.2m to avoid browsing.

Showing harvested and unharvested Leuceana lucocephala trees in one of the on-farm trial site.

9 Inter cropping

Inter-cropping is practice of planting trees together with crops in the same unit of land. The main reason for inter-cropping is to maximize use of land and to diversify farm products. Where inter-cropping is practiced, farmers weed trees while weeding the crops. Recommended management practices for various inter crops are given below;

9-1 Intercropping with maize/beans

Maize/Beans should be planted 0.5m－1m away from the trees. The root depths of the intercrop ranges between 30cm－40cm, so the effect of tree/crop competition is minimal. Where spacing of the planted trees is 4m x 4m, 2 lines of beans and 2 lines of maize are recommended. Where rainfall is low, only beans should be

intercropped. Intercropping with these annual can be done for 2 – 3 years depending on tree species and spacing of the trees.

Showing *Melia volkensii* and *Grevillea robusta* intercropped with maize.

9-2 Intercropping with cowpea

Cowpeas have deep roots and their cropping period is long.
They therefore exert more competition for moisture than maize and beans. Spacing of cowpeas should be wider than the spacing of beans. The distance of cowpea to the planted trees should be more than 1m. Cowpea can be intercropped even during the short rain season.

Showing *Melia volkensii* intercropped with cowpeas.

9-3 Intercropping with pigeon pea

Root of pigeon pea extend up 1m, and require 8—9 months to mature. So water consumption is higher as compared to other crops. Distance between pigeon pea and the planted trees should be 2m(1 line between the row of trees).