TECHNICAL RESULTS

TIVA PILOT FOREST

TIVA PILOT FOREST from Kwabonza hill (Apr. '02)

SOFEM / KEFRI

October 2002

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Introduction

The Social Forestry Training Project (SFTP) was started on November 1987 as the first Japanese forestry technical cooperation in Africa. The afforestation experiments have been done through SFTP I, SFTP II and Society Forestry Extension Model Development project (SOFEM) in 17 years. Many Japanese experts and Kenyan counterparts have been concerned in the experiments since beginning of the SFTP. Basic Afforestation technologies in Asals have been established form the result by the trial and error. This is the report which compiled various result of the afforestation experiments on TIVA Pilot Forest by the SOFEM.

At the time of the beginning of SETP, the land preparation was done remaining natural vegetation, slash weeding and bottle watering due to the soil conservation. The afforestation had been done 40ha every year, but most of the planted area can not be seen now. The water competition between trees and weeds was noticed by SFTP II, because of the trees on the spot weeding and the belt weeding performed better than slashing. The tree surviving and growth were drastically improved with the complete weeding and water catchment at the SFTP II. Various experiments have been done by SOFEM with the advice of Professor Yahata in Kyushu University for the verification of the techniques.

The tree growth with complete weeding is more than four times with the slashing, amount of the soil erosion with the complete weeding and water catchment is 1/6 of the control. It was proved that the effect of the complete weeding is not only the tree growth but also soil conservation.
The farmers had not been guided inter cropping due to the encouragement of water competition between trees and crops, but the result of the experiment shows that cultivation have not influenced the tree growth, and crops which was unexpected could be harvested. It was proved that inter cropping is one of the solution of the tree weeding which have to be done at the same time of the farming on farm forestry.

The technical results which are compiled in this report shows possibility of forestry in Asals, but the all most are basic technologies, more practical experiments must be done for establishment farm forest.

These technologies have been established through Project activities only in 17 years, and this result is very huge. We would like to appreciate the activities of all experts and counterparts worked on SFTP and SOFEM, and hope that these technologies will be used in KEFRI, FD, other organizations and farmers.

Samuel Auka
Taiki Kobayashi

Technical result of the Pilot Forest

P.O	1.1.2.1	Trial	Water catchment	
Compartment			Map No.	⑫
Species	*Senna siamea*		Area	0.54 ha
Year Planted	1994		Period	Nov. 1995 ~ 1999
Additional				
Responsible persons	Samuel Auka			

Purpose of the Trial:
To prove the validity of water catchment structures as a way of soil erosion prevention and enhancement of early tree establishment by encouraging faster root development.

Method of the Trial:
Three catchment types were tested i.e *Turkana*(square shaped), W and V- shaped structures were set up in November, 1995 in the afforestation area where *Senna siamea* was planted in 1994. Assessment on tree performance and survival ended in 1999.

Experiment progress:
From the results tree performance was best under *Turkana*, followed by W- shaped and V- shaped catchments, respectively.
But since *Turkana* type is large and therefore labour intensive and yet W- shape proved just as effective, the latter was recommended and adopted. There is need however, for further tests especially involving other tree species.

Future plan:
Even though the catchment technology has widely been adopted as an early tree establishment strategy by farmers, further observations and validation is necessary with other tree species like *Melia volkensii.* It is also necessary to carry out tests aimed at determining wood quality/ properties.

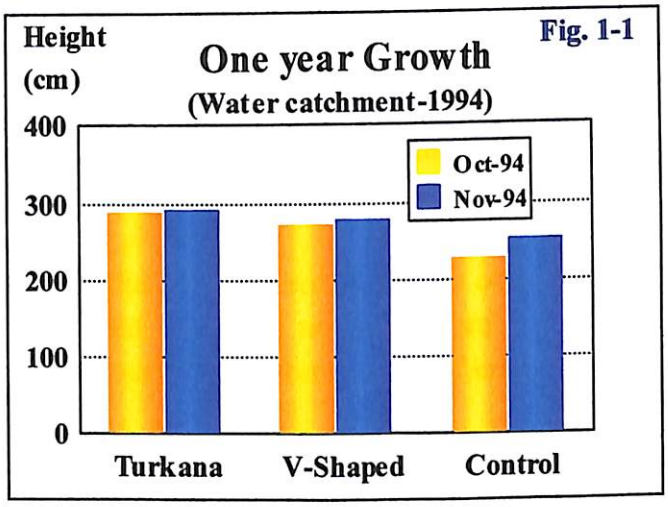
Attached materials :

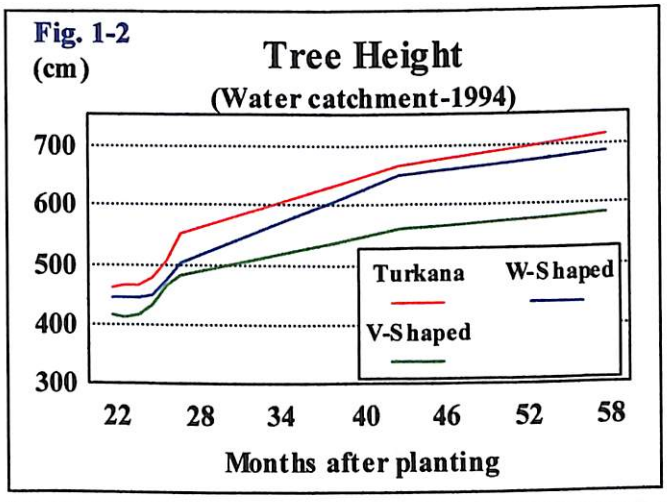
Water catchment

1. *To determine the best planting time (October or November) using different water catchment structures.*
2. *To determine the effect of different water catchment structures.*

1.The experiment was established in October and November 1994, respectively. The test species was *Senna siamea*.Two treatments (Turkana and V- shaped catchments) and a control were applied. The plots were completely weeded during the period. Assessments were done for upto one year.

2. Three types of treatments [Turkana (Ground Divisions), V-shape and W-shape] were established on the experiment site planted with *Senna siamea* and assessments done upto 1999.
Pruning (Height of pruning was not defined) was done on all plots in 1997, and complete weeding carried out until 1997.





1) Difference of tree growth after one year
Trees planted in November showed a little higher height growth than those planted in October. The same trend was observed on all the plots.
Turkana (ground division) plot showed best performance while V-shape plot showed a little lower than Turkana but was better than control plot.

2) Tree height with types
Water catchments were established one year after planting. Fine growth was observed in the order of Turkana, W-shape and V-shape from the second year. There is a clear difference between V-shape and other two types, but there was no big difference between Turkana and W-shape after 1997.

Table 1-1
Height Calculation

Slope	100 mm	50mm
10 °	69 cm	54 cm
6 °	50 cm	39 cm
5 °	44 cm	34 cm
4 °	39 cm	30 cm
3 °	33 cm	25 cm
2 °	26 cm	20 cm
1 °	17 cm	13 cm

3) Catchment size corresponding to the slope
The minimum size of the catchment (the height of the embankment) that cannot permit runoff

outflow during maximum rainfall was calculated and shown on the table.

The condition of the calculation:

Maximum rainfall : 100 mm, 50 mm

Spacing 4 × 4

Catchments :W-shape, 90°

The thickness of the bank and the soil permeation of the water were ignored.

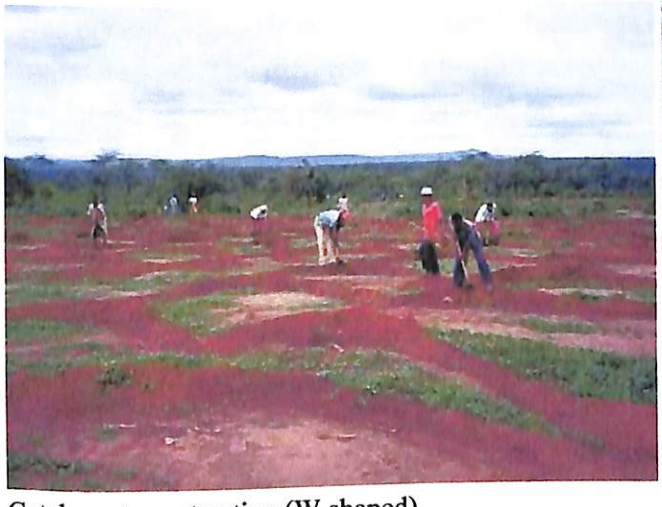
4) Conclusion

The November planted area showed good tree growth after one year. This could be attributed to the fact that soil moisture build up was already enough in November when the planting was done.

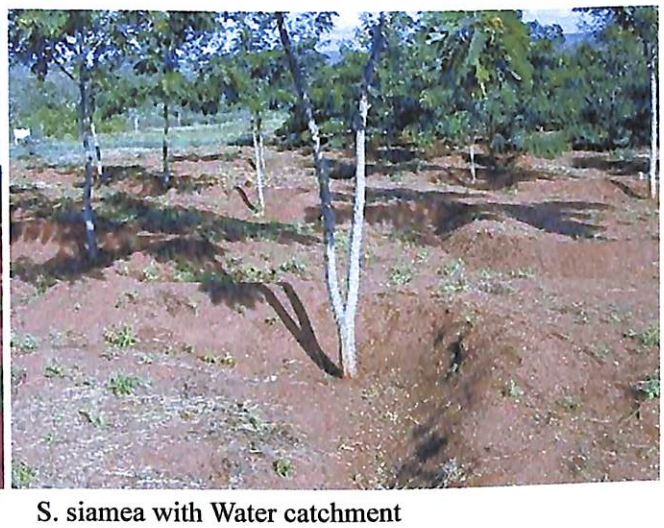
According to the result of Tree performance with types, Fine growth was observed in the order of Turkana, W-shape and V-shape from the second year.

This result can be said as the thing that an original hypothesis (A difference comes out in the tree growth by the ability of the water catchment) is proved. There is no big difference between Turukana and W-shape after 1997, but V-shape plot shoes low performance. Difference of tree growth was shown strongly without complete weeding.

Water catchment roles not only water collection to trees but also the function to control soil erosion is important. When water overflows from catchments, the run off power becomes strong, and it is connected with suggesting soil erosion conversely. Therefore effective catchment size was calculated. Farmers can construct and repair catchments which height is less than around 30 cm by themselves. According to the calculation, catchment must be constructed on the land slope less than 3°(height=33cm) in case of maximum rainfall 100 mm, and on the land slope less than 5°(height=34cm) in case of maximum rainfall 50 mm. It must be required other methods in the steep areas.



Catchment constraction (W-shaped)



S. siamea with Water catchment

Technical result of the Pilot Forest

P.O	1.1.2.2	Trial	Mulching	
Compartment			Map No.	⑫
Species	*Senna siamea*		Area	0.05 ha
Year Planted	1995		Period	Dec. 1995 ~ Apr. 1999
Additional	Sun heat shield effect and mulching			
Responsible persons	Samuel Auka			

Purpose of the Trial:
Investigation was done to determine the effect of mulching on growth of *Senna siamea* and in conservation of soil moisture levels.

Method of the Trial:
Murram, Sand mulching and Control plots were set up on a *Senna siamea* plot, which were planted in December, 1995. Parameters on height of tree and root diameter were assessed.
The mulch thickness was between 7-10cm.

Experiment progress:
During the first one year of growth, murram mulching gave a better performance than the other two. However from the end of the first year onwards there was no clear difference between murram and sand mulching. The general impression therefore was that where soil surface cover was present, trees showed better performance presumably because mulching material reduced soil moisture loss. The difference in performance between the two mulching materials could be explained by the fact that one material encouraged the loss of more surface moisture than the other. This can be attributed to the coarseness and fineness of the respective materials i.e. finer materials encourage more moisture loss through capillary action.
In the second year, the disappearance of mulching effect could have been as a result of a reduction of the amount of surface evaporation due to development of tree crown.
Verification plot established in 1999 (1.1.2.4.2)

Future plan:
Verification of the above phenomenon is necessary.

Attached materials :

Mulching

RESULTS

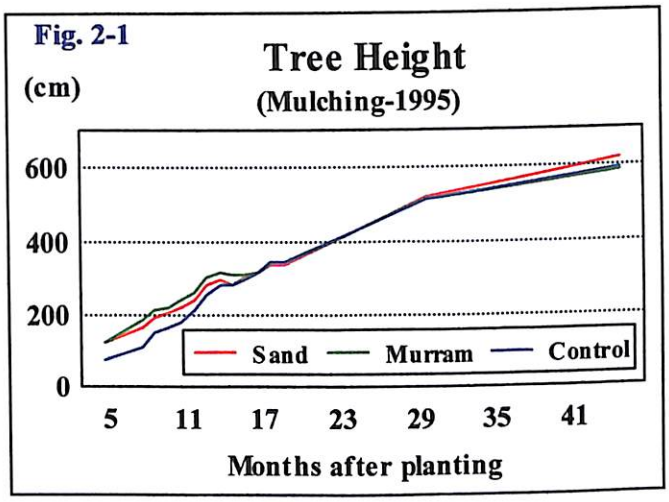
1) Tree height

There was no difference of tree height between sand and murram 5 months after planting and average of the tree height in both treatments was 120cm. The trees in control plots showed an average height of 76cm. Height difference between the plots reduced gradually from the first year. Average height in all plots was 310cm at age $1^{1/2}$years.

2) Tree Diameter (Dgl)

Diameter at ground level shows the same trend as tree height. Trees in the sand and murram plots showed 2.5cm and control plots showed 1.6cm, 5 months after planting. The difference reduced gradually with age.

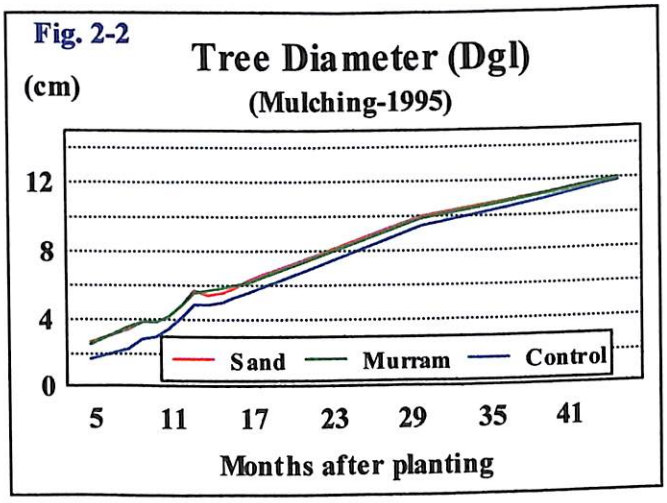
Fig. 2-1



3) Surviving rate

The survival rate in the murram and sand plots showed 100% during survey period. Survival in the control plot showed 94%, 5 months after planting, which reduced to 92% at the end of the measurement.

Fig. 2-2



4) Conclusion

Mulched plots show the tree growth performance (Dgl and Height) better than control plot in first 1 year. The survival rate was lower in control plot, at 94%, than in mulched plots, 5 months after planting. It shows that mulching had an effect of reducing evaporation from the soil. But the difference between mulched plots and control reduced after the second year.

It seems that the development of the tree crown increased the amount of shade on the plots. The shading effect therefore reduced the amount of evaporation thereby reducing the effect of mulching. There was no big difference between mulching materials used.

According to the above results, it was observed that mulching is effective for tree growth within 1 year after planting.

For ease of application it is very important to find/use mulching materials that farmers can get easily without having to spend a lot of resources collecting sand and murram.

Possible reasons for less mulching effect after second year are under verification on the Sun heat shield effect experiment and grass mulching experiment.

Technical result of the Pilot Forest

P.O	1.1.2.3 & 1.1.2.4.1	Trial	Weeding (Soil moisture)	
Compartment			Map No.	①
Species	*Senna siamea*		Area	0.56 ha
Year Planted	1999		Period	Nov. 1999/11 ~
Additional				
Responsible persons	Samuel Auka			

Purpose of the Trial:
The trial was established with the aim of verifying the effect of complete weeding and its relation to ground water movement for the benefit of extension agents and farmers. The trial was a follow-up to an earlier one that had been tried on a smaller scale in 1995. The delay in arrival of soil moisture sensors at that time led to a change of schedule in implementation.

Method of the Trial:
A trial plot with four treatments i.e. complete weeding (with trees), slash weeding (with trees), complete weeding (without trees) and slash weeding (without trees) replicated four times was set up in November 1999. Trees species planted was *Senna siamea*.
Soil moisture sensors were then installed on each of the plots.

Experiment progress:
A clear difference was recognised in tree growth between complete weeding and slash weeding. Crown cover was well spread in complete weeding plot. The good performance experienced on this plot could be attributed to faster establishment due to effective use of ground moisture.
Soil moisture condition on completely weeded plot was more stable along the soil profile than on slash weeding plot.

Future plan:
Though it is understood how competition for ground water influences tree growth/survival, the effect of complete weeding on surface soil particles (erosion) need more investigation.

Attached materials :

Weeding (Soil moisture)

1) Tree Height

Average tree height in completely weeded plot (A1) was 5.1m at 2 years and 9 months after planting (August 2002). While in the slashed plot it was 3.2m during the same period. The tallest height in complete weeding is 6.1m and in slashing is 4.6m.

2) Diameter (Dbh)

Average Dbh in completely weeded plot (A1) was 6.4cm, 2 years and 9 months after planting. On the slashed plot it was 3.0cm. The largest diameter in completely weeded plot was 8.2cm while in slashed plot it was 5.3cm.

3) Tree volume

The tree volume, calculated from above Dbh and tree height was 0.009m3 in complete weeding and 0.002m3 in slashing. Growing stock of complete weeding is 5.6m3/ha and in slashing is 1.3m3/ha. The stand density is 625/ha on both plots. Current annual increment (CAI) is 2.0m3/year in complete weeding and 0.47m3/year in slashing plots, respectively.

4) Survival rate

Survival rate is 69% in completely weeded and 67% in slashed area (August 2002).

5) Soil moisture

Soil moisture in completely weeded area from January 2001, is higher than in slashed area. The difference however, reduced after October 2001. The dispersion of the data in every plot is big.

Fig. 3-1 **Layout of Weeding Experiment**

A1 Planted C. weeding	A4 C. weeding	A3 Slashing	A2 Planted Slashing
A2 Planted Slashing	A1 Planted C. weeding	A4 C. weeding	A3 Slashing
A3 Slashing	A2 Planted Slashing	A1 Planted C. weeding	A4 C. weeding
A4 C. weeding	A3 Slashing	A2 Planted Slashing	A1 Planted C. weeding

Fig. 3-2

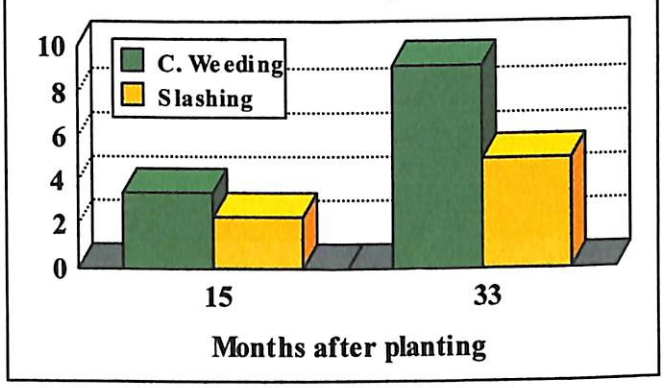
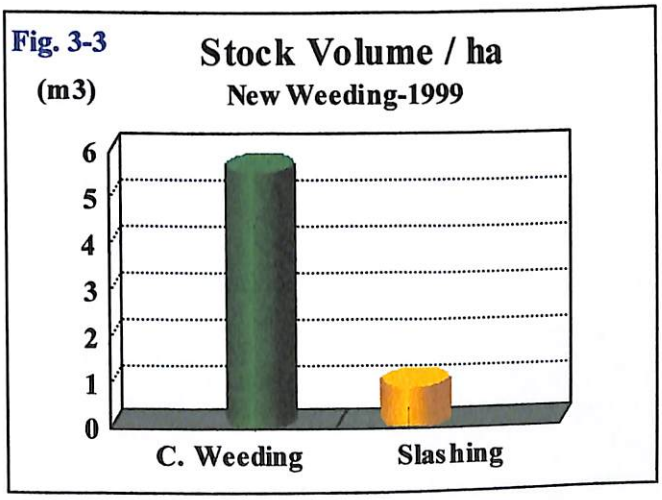


Fig. 3-3



6) Conclusion

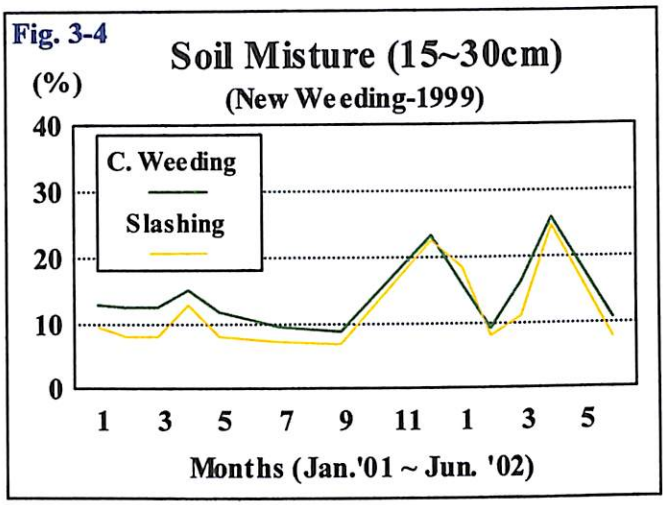
The importance/effect of complete weeding was clear and tree growth was two times higher than in slashing area as observed from experimental data.

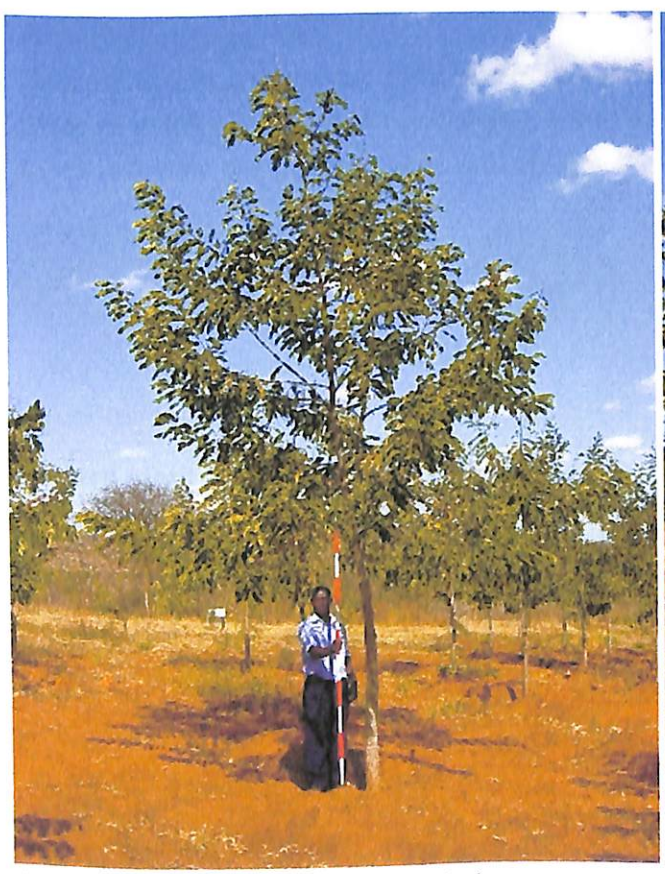
Growing stock and current annual increment in the completely weeded area were more than 4 times that of slashed area (Calculated by Japanese tree volume table). The soil moisture content was measured along the soil profile monthly. And average soil moisture in complete weeding is a little

higher than slashing area. But it is no cleared because the dispersion of the data in every plots are big.

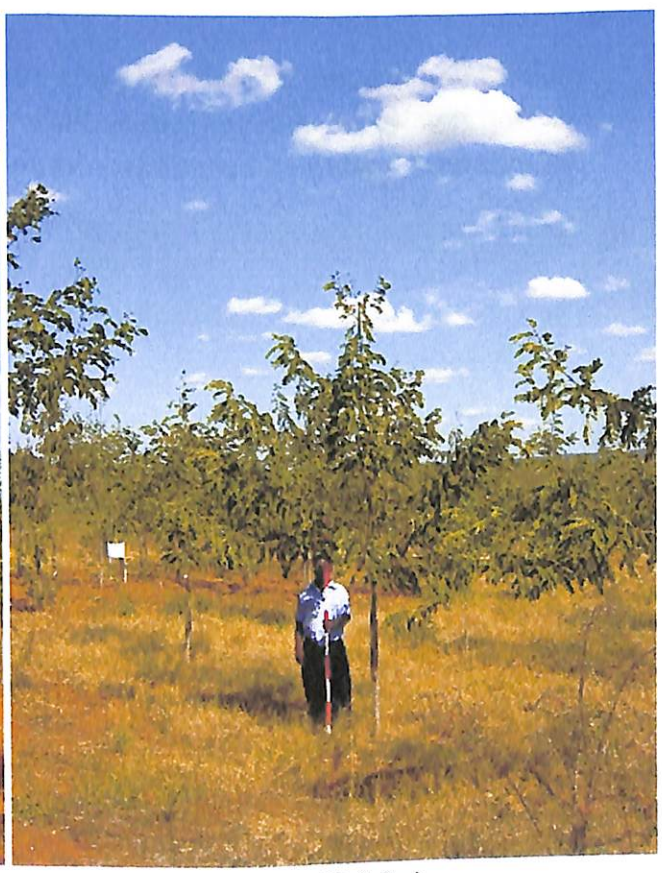
Data analysis is not accurate because the period of data collection was short (2 years and 9 months), but the predominance of complete weeding was very clear. This experiment must be continued and other experiment must be established for verifying the effect of complete weeding.

Fig. 3-4





Completely weeded (Dbh=6.4cm, =5.1m)



slashed plot (Dbh=3.0cm, H=3.2m)

Technical result of the Pilot Forest

P.O	1.1.2.3	Trial	Weeding (Soil erosion,)	
Compartment			Map No.	①
Species	*Senna siamea*		Area	0.56 ha
Year Planted	1999		Period	Nov. 1999 ~
Additional				
Responsible persons	Samuel Auka			

Purpose of the Trial:
Based on the technological experiences of tree establishment in arid and semi arid areas, an argument was raised about whether it was appropriate to recommend complete weeding without considering its potential to promote erosion. A trial was therefore set up to test the above hypothesis.

Method of the Trial:
A site with a gentle slope was selected where a tipping bucket was installed on each of the 5 representative plots of (planting trees + complete weeding), CS2 (planting trees + slash weeding), CS3 (slash weeding), CS4 (complete weeding) and CS5 (control) were set up, and quantity and the amount of soil being carried away were measured under the soil surface way of the rainwater which fell in the zone.

Experiment progress:
Data collection is on going. Preliminary results show complete weeding prevents soil erosion twice as much compared to control plot. From the result, even if complete weeding is done two times in a year, the occurrence of soil erosion is somehow controlled by water catchments.

Future plan:
Though complete weeding and the validity of management by water catchment became clear, further research is necessary.

Attached materials :

Weeding (Soil erosion)

The following 5 experimental plots were installed in the new weeding experimental area, and measurement of the water run off under the soil surface and amount of soil erosion under the soil surface were started in 2000.

Fig. 4-1

Layout of
Run off and Soil erosion experiment-1999

CS 5	CS 4	CS 3	CS 2	CS 1
Control	C. weeding	Slashing	Planted Slashing	Planted C. weeding
	Catchment	Catchment	Catchment	Catchment

Species : *Senna siamea* **Planted :** Nov, 1999
Spacing : 4 × 4 m **Slope :** 4.3°

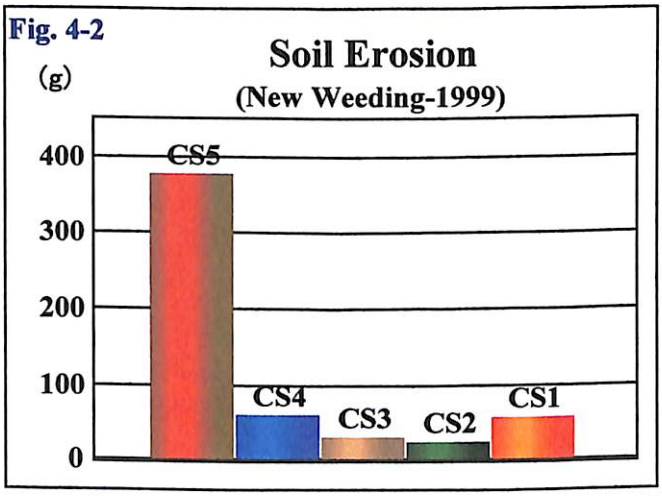
1) Water run off under the soil surface

In the plots with micro catchments (CS 1, 2, 3 and 4), it was observed that water run off under the soil surface in the all plots was under 1 mm. However, in the plot with no water catchment and no weeding (control), it was observed that water run off was 7 mm.

2) The amount of soil erosion

The graph shows the total amount of eroded soil from each plot. The temporary specific gravity of the soil was considered as 1 with finding value in total, and converted into the thickness of the soil. The comparison between each plot is explained as follows.

Fig. 4-2



1. Completely weeding plots (Cs1 and CSs4) show that amount of soil erosion is two times higher than in slashed plots (Cs2 and Cs3). Annual soil erosion was 0.06 mm in the first two plots.
2. Planted plots (Cs1 and Cs2) show that amount of soil erosion is little less than in non- planted plots (Cs3 and Cs4). However, the possibility of influence of land slope on planted trees is not clear.
3. Control plot (Cs5) with no water catchments and no trees planted showed that soil erosion was 6 times higher than in completely weeded areas. Annual soil erosion was 0.38 mm on the plot.

3) Conclusion

It was previously regarded that complete weeding encouraged a decline in future land productivity due to the complete removal of surface vegetation leading to soil erosion. But according to the results above, surface vegetation alone cannot control soil erosion effectively.

It was however observed that complete weeding combined with water catchments could control soil erosion upto 6 times more as compared to control plot.

Almost any farmer can use this method in Kitui district, because most of agricultural land in Kitui has gentle slope.

Equipment of soil erosion

CS1 tree planting, complete weeding, Micro catchment

CS2 Tree planting, slashing and Micro Catchment

CS5 Control

Technical result of the Pilot Forest

P.O	1.1.2.4.2	Trial	Sun heat shield effect and mulching	
Compartment			Map No.	②
Species	*Senna siamea*		Area	0.61 ha
Year Planted	1999		Period	Nov. 1999 ~
Additional				
Responsible persons	Samuel Auka			

Purpose of the Trial:

To verify the effect of mulching on tree performance. The trial was first established using murram and sand as mulching materials. During the first one year of growth, murram mulching gave a better performance than sand. However from the end of the first year onwards there was no clear difference between murram and sand mulching.

Hypothetically, one reason for uniformity in performance could be attributed to influence of tree canopy cover on the forest floor hence less sun heat penetration. Silk gauze of about 75% density was therefore used to control solar heat effect on the mulched plots.

Method of the Trial:

A trial consisting of six treatments, replicated three times was established in 1999 on a *Senna siamea* plot. Mulching materials applied included murram and tree leaves, which substituted sand. A silk net gauze was used to control solar heat on the plots.

Assessment of performance on tree height, root diameter and survival rate was conducted

* The thickness 10cm
* silk gauze (75% density)

Experiment progress:

Accumulated data may not be reliable because trial prescriptions were unclear during initial stages of establishment

Future plan:

Further verification is necessary

Attached materials :

Sun heat shield effect

It was observed that mulching (murram or sand) improved tree growth by upto 60% (mulching experiment 1995). The evaporation from the soil was probably influenced by the development of tree crown thereby decreasing mulching effect after the second year. The experiment was established in November 1999 and tree species used was *Senna siamea*. Complete weeding, slashing, murram mulching, grass mulching and sun heat shield combined were taken as treatments. Assessments were later taken on tree growth, survival and die back rate.

Fig. 5-1

Layout of Sun hert Shield-1999

A1 Murram	A4 S. shield Murram	A3 Leaves	A6 Slushing	A5 C. Weeding	A2 S. shield
A2 S. shield	A5 C. Weeding	A4 S. shield Murram	A1 Murram	A6 Slushing	A3 Leaves
A3 Leaves	A6 Slushing	A5 C. Weeding	A2 S. shield	A1 Murram	A4 S. shield Murram

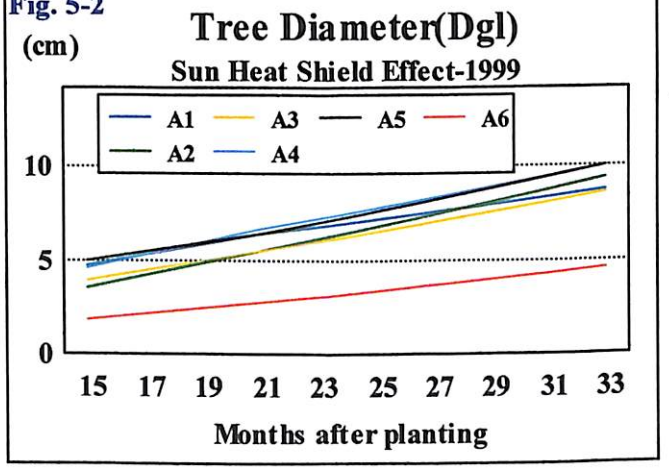
1) Tree Growth

The best growth (height 5.2m and diameter 10cm) was observed where murram mulching and silk gauze were used together.

Where other mulching materials (murram, leaves alone) were used, growth was a little lower i.e height is 2.5m and Dgl is 4.5cm.

Growth was lower by half in the control plot (slashing only) as compared to where mulching was done using murram and gauze.

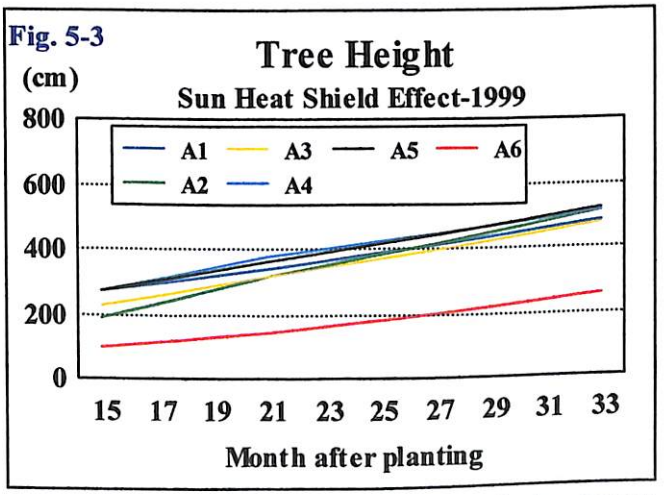
Fig. 5-2



2) Surviving Rate

Survival rate was between 89~100% in A1~A5, 1 year and 9 months after planting. It was very low in A6 at 22%, which is half as compared to the other 5 plots.

Fig. 5-3



3) Conclusion

Tree growth in all plots showed almost constant growth except in A1, which was a different result compared to the mulching experiment of 1995.

The growth and survival rate in A6 (slashing) was obviously lower than in the other 5 plots, probably because of the difference in weeding method. The difference between each treatment could be attributed to the delay in weeding because of much.

Weeding

2 years after planting

Experiment plot

Complete weeding sun heat shield

Technical result of the Pilot Forest

P.O	1.1.2.4.3 & 1.1.2.4.4	Trial	Water stress and Evapo-transpiration	
Compartment			Map No.	①④
Species	*Senna siamea*		Area	0.56 ha
Year Planted	1999		Period	Nov. 2000 ~
Additional				
Responsible persons	B. Kigwa			

Purpose of the Trial:
To study the relation between plant water uptake and its effects on plant physiological stability.

Method of the Trial:
1. Soil evaporation: comparative measurement of amount of soil evaporation on complete weeding and slash weeding plots.
2. Evaporation from tree leaf, pore conductance, water potential and sap way water uptake (HPV) measurement of photosynthesis
3. Tree electronic transmission speed (ETR)
4,Root system and biomass

Experiment progress:
The experiment have been done by Mr. B. Kigwa under the assistance of Professor Yahata in Kyushu University. The root system on the difference of weeding methods and tree biomass analysis was done in Intercropping experiment at August 2002.
Data analysis have been done in Japan and report presentation will be done later.

Future plan:
Data collection on tree water uptake continues. Analysis will be done later. It must be done on other species.

Attached materials :

Technical result of the Pilot Forest

P.O	1.1.3.1	Trial	Spacing	
Compartment			Map No.	⑫
Species	*Senna siamea*		Area	1.07 ha
Year Planted	1996		Period	Jul. 1999 ~
Additional				
Responsible persons	Samuel Auka			

Purpose of the Trial:
To determine the optimal espacement of senna siamea for maximum product output.

Method of the Trial:
The trial was established in 1997 on a plot that had been planted in November 1996.
Five espacement regimes (1.0m×1.0m, 2.0m×2.0m, 3.5m×3.5m, 4.0m×4.0m and 5.0m×5.0m) were tried. The test species was *Senna siamea*. Measurements on tree height, root diameter, surviving rate and die back were conducted.

Experiment progress:
Wider spacing appeared to be directly related to better tree performance but inversely related to occurrence of die- back incidence. This can be explained by the fact that wider spaced tree roots are able to benefit from more nutrients with minimal competition. The crown is also more exposed to larger photosynthetic area hence better growth performance. Close spacing, on the other hand, induces formation of weak (thin) and long stems. And during drought (stress) due to high competition for soil moisture, die back incidences are reported. Currently a 4m x 4m spacing interval is most preferred even on farmlands. The spacing interval can accommodate not only animal drawn but also machinery drawn farming implements.

Future plan:
The trial objective has been achieved as far as one species (*S. siamea*) is concerned. Further studies with other utility tree species should be done.

Attached materials :

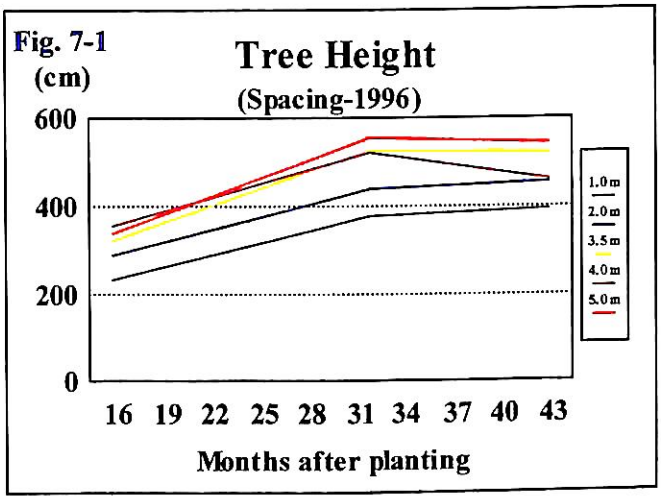
Spacing

The trial was established in 1997 on a plot that had been planted in November 1996.
Five spacement regimes (1.0m×1.0m, 2.0m×2.0m, 3.5m×3.5m, 4.0m×4.0m and 5.0m×5.0m) were tried. The test species was *Senna siamea*. Assessments on tree height, root collar diameter, survival and die back rate were conducted between March 1998 and June 2000.

1) Tree height

It was observed that wider spacing encouraged better growth. Height growth was 3.9m in the 1.0m x 1.0m plot and 5.4m in the 5.0m x 5.0m plot at 4 years after planting.

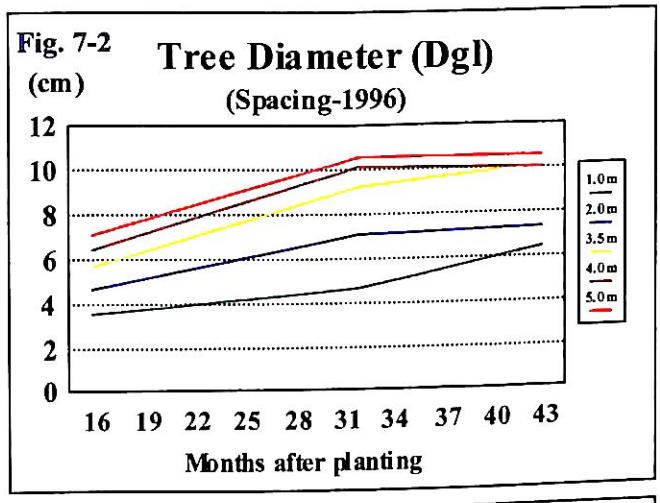
Fig. 7-1



2) Tree diameter (Dgl)

Diameter growth showed the same trend as in height. The 1.0m x 1.0m gave 6.5cm growth while 10.6cm growth was observed in 5.0m x 5.0m plot. The 3.5m x 3.5m and 4.0m x 4.0m showed a growth of about 10.0 cm 4 years after planting.

Fig. 7-2



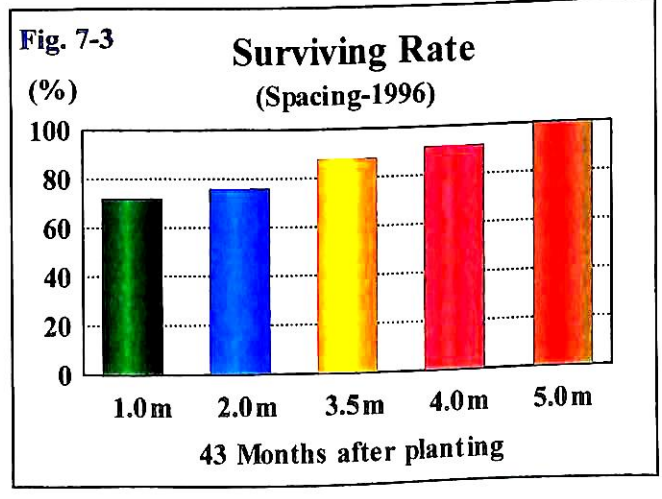
3) Surviving rate

Spacing interval was observed to have an influence on survival rate. It was 100% in the 5.0m x 5.0m plot and 72% in the 1.0m x1.0m plot at 4 years after planting.

4) Stock amount

According to the Stock amount, which was calculated from the tree growth (Dbh=Dgl× 0.63) and survival rate, the 1.0mx 1.0m plot showed best performance at 4 years after planting with 22.5m^3/ha. In the 2.0m x 2.0m plot the volume was 8.4m^3/ha, which is half of the amount in 1.0mx 1.0m plots. The growth rate in the 1.0m x 1.0m plot is fine but in the other 4 plots, it has been decreasing since 2 $^{1/2}$ years after planting.

Fig. 7-3



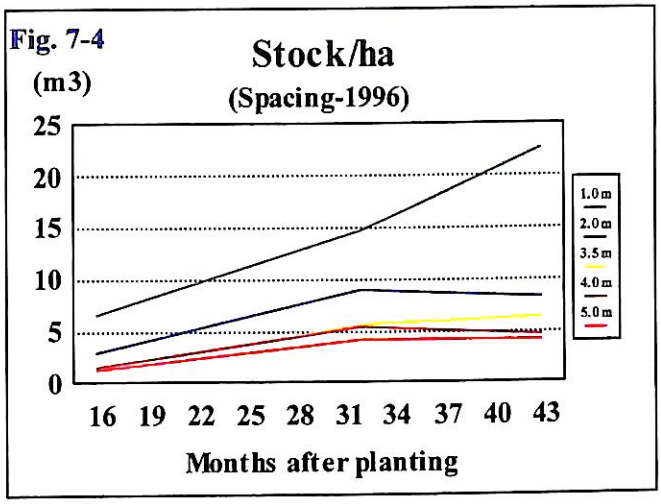
5) Conclusion

The data was recorded three times; at 1 $^{1/2}$, 2 $^{1/2}$ and 3 $^{1/2}$ years after planting.
It was observed that tree growth improved with wider spacing.

Survival rate also followed a similar trend as tree growth. It seemed that tree growth is influenced by, among other factors, availability of soil moisture which in itself is influenced by spacing.

But, stock amount per unit area showed that tree growth and growth rate in the 1.0m x 1.0m plot was better than the other 4 plots. Further studies must conducted to determine suitable spacing, and another experiment area must be established for other useful tree species e.g *Melia volkensii*.

Fig. 7-4



1.0×1.0m

2.0×2.0m

3.5×3.5m

4.0×4.0m

Technical result of the Pilot Forest

P.O	1.1.3.2	Trial	Pruning	
Compartment			Map No.	⑭
Species	*Senna siamea*		Area	0.48 ha
Year Planted	1996		Period	Feb. 1999 ~ Aug. 2001
Additional				
Responsible persons	Samuel Auka			

Purpose of the Trial:

Even though some tree species e.g *Senna siamea* are known to be drought tolerant, many cases of shoot die-back are still reported when the trees are stressed. This can be avoided so long as a balance between evapotranspiration and ground water supply is achieved. One way towards achieving the balance is through pruning. The trial therefore aims to determine the optimal pruning regime for *Senna siamea*.

Method of the Trial:

The trial was established in 1999 on a *Senna siamea* plot, planted in 1996.
Three types of pruning levels were set up: -Pruning rate ½ height, $^{2}/_{3}$ height, Control.
Measurements on tree height, diameter, surviving rate and die back were investigated.

Experiment progress:

There was no difference in height growth in all treatments. Pruning intensity inversely affected diameter growth. Trees pruned at 2/3 were observed as not wind -firm. It was however clear that pruning at whatever level prevented the occurrence of dieback.

Future plan:

The objective of the investigation was achieved. Future trials should examine pruning in tree management systems and involve other species.

Attached materials :

Pruning

Senna siamea has been widely planted in the Pilot Forest because of its drought tolerance and resistance to termite attack. But it is prone to die back incidence in the dry period. The experiment plot was established for verification of pruning effect.

The trial was established in 1999 on a *Senna siamea* plot, planted in 1996. Three types of pruning levels were set up: -Pruning rate ½ height, $^{2}/_{3}$ height and Control.

Measurements on tree height, diameter, survival rate and die back were investigated.

1) Tree growth

The graphs show that there was a clear difference in growth between the treatments. Dbh in the $^{1/2}$ pruned plot is higher than $^{2/3}$ pruned plot while tree height in the $^{1/2}$ pruned is lower than $^{2/3}$ pruned. Control plot recorded the lowest growth.

Fig. 8-1

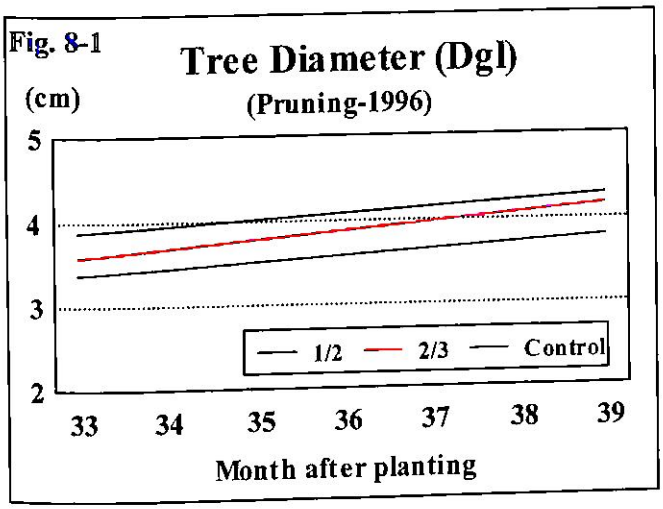
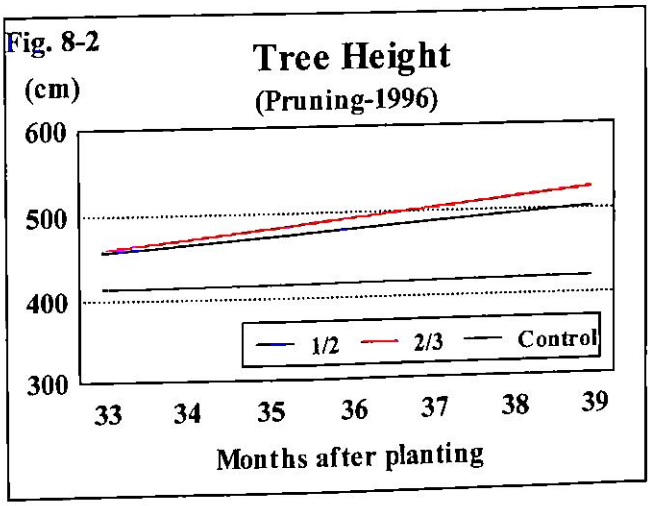


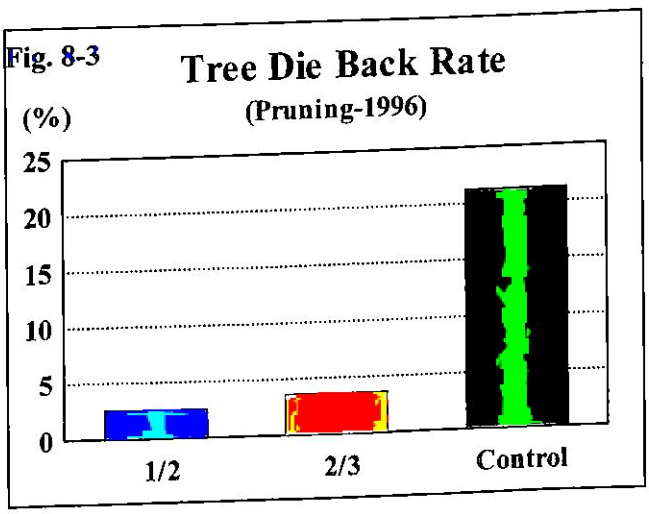
Fig. 8-2



2) Die back

The average die back rate in the control plot is about 22%. The die back rate in the pruned plots is less than 1/4 of the control plot.

Fig. 8-3

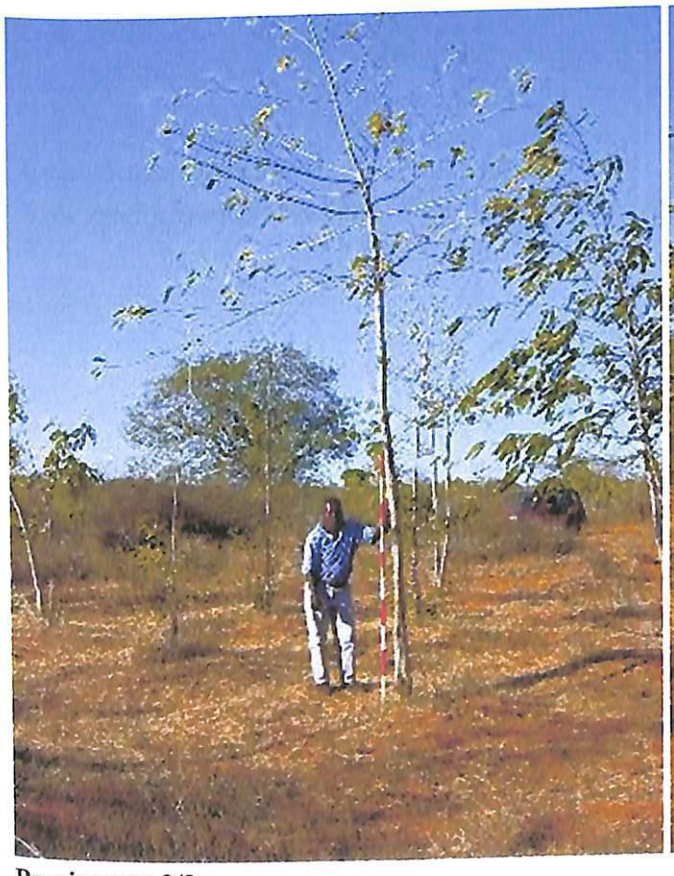


3) Conclusion

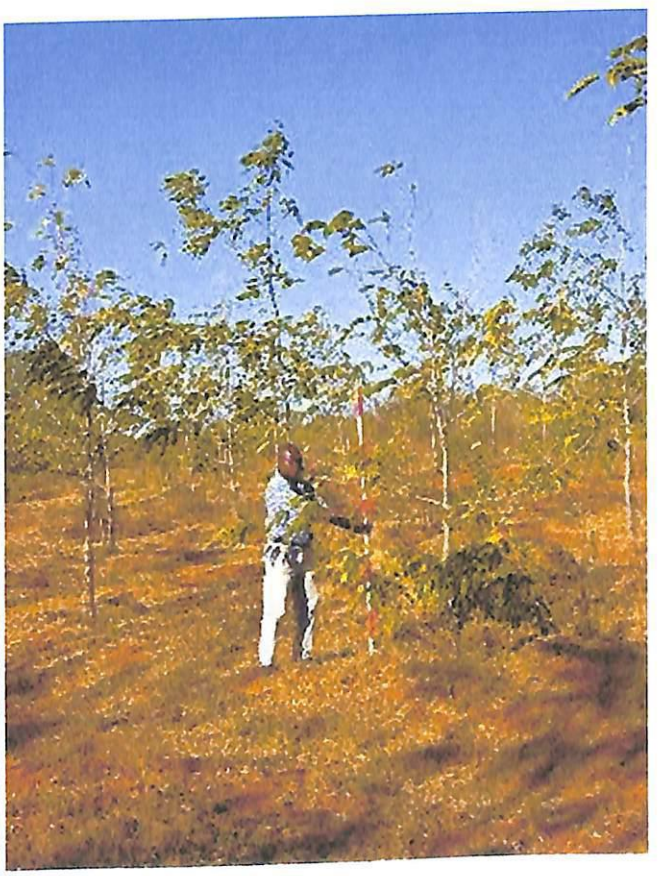
It was observed that pruning had an effect on tree growth as well as on dieback incidence. It shows that pruning reduces water stress in the crown and leading to higher growth less dieback.

Pruning

Pruning height 1/2



Pruning rate 2/3



Control

Technical result of the Pilot Forest

P.O	1.1.1.4	Trial	Thinning	
Compartment			Map No.	⑫
Species	*Senna siamea*		Area	0.42 ha
Year Planted	1993		Period	Jul. 1999 ~
Additional				
Responsible persons	Samuel Auka			

Purpose of the Trial:
To investigate thinning influence on tree growth.To determine optimal thinning rate.

Method of the Trial:
The trial was established on a *Senna siamea* plot planted in 1993.
Two thinning intensities and a control were set up:- 48%-52%, 60%-70%, 0% (control)
Assessment of tree height and the root diameter was later done.

Experiment progress:
Tree performance improved with higher thinning intensity. There was

Future plan:
Further investigation is required especially for other species in order to design diameter class tables.

Attached materials :

Thinning

The biggest factor, which decides the tree growth in ASALs, is water. There is a limit in the amount of water which one tree can use by planting density. It seems that much water is available by increasing the occupation areas of one tree by thinning. The trial was established on a *Senna siamea* plot planted in 1993 at a spacing of 2m×2m. Thinning was later done by between 48%~70% in 1996.

1) Tree growth

Dbh at 3 years after the thinning (Jul, 1999) was 9.2cm in the control plot, 10.8cm in the 48~52% plots and 13.3cm in the 60~70% plots.

The tree height shows a similar trend of 6.5m in the control plot, 7.0m in the 48~52% plot and 7.4m in the 60~70% plots.

Fig. 9-1

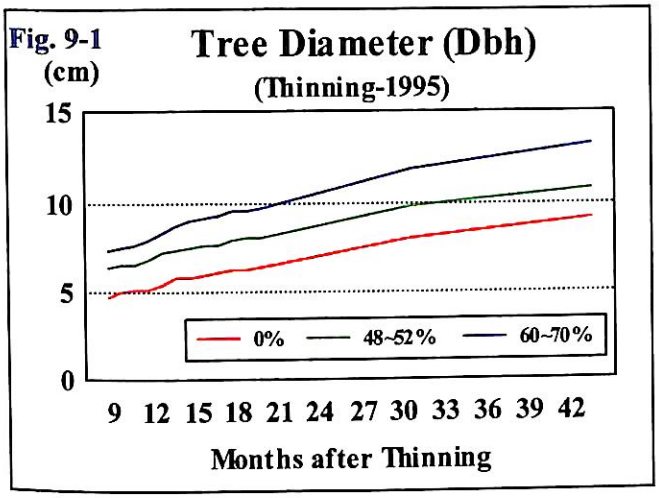
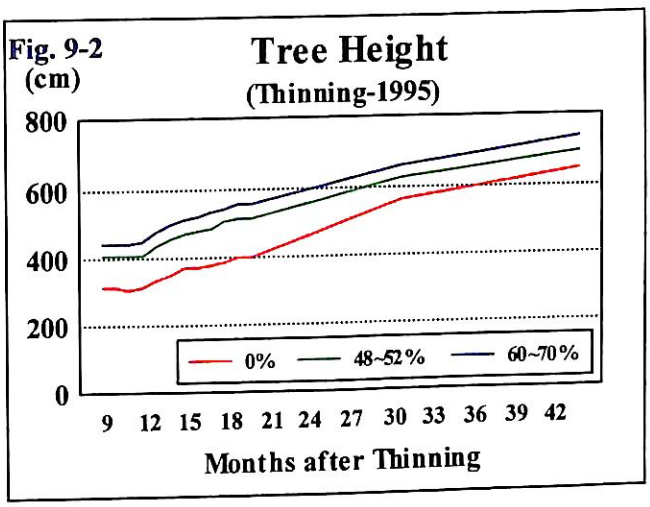


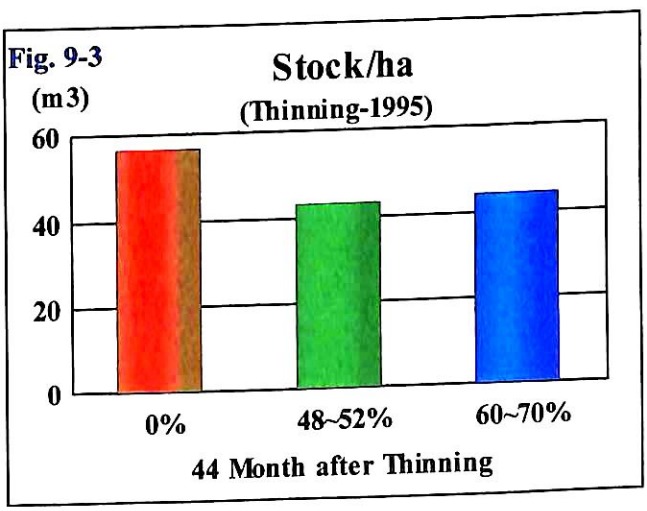
Fig. 9-2



2) Stock

Stock per unit area, calculated from Dbh and tree height, was 57m^3/ha in the control plot which was the highest, 45m^3/ha in the 60~70% plots and 43m^3/ha in the 48~52% plot.

Fig. 9-3



3) Conclusion

It was observed that higher thinning intensity induced growth increment. This was probably because thinning increased the area occupied by the remaining trees.

The trial area was however limited in scope and data collection erratic. A new experimental plot should therefore be established for verification of thinning.

Technical result of the Pilot Forest

P.O	1.1.3.4	Trial	Coppicing	
Compartment			Map No.	⑬
Species	*Senna siamea*		Area	0.36 ha
Year Planted	1996		Period	Feb. 1999 ~
Additional				
Responsible persons	Samuel Auka			

Purpose of the Trial:
To determine optimal coppicing levels for tree product utilization.

Method of the Trial:
The trial was established in 1999 on a *Senna siamea* plot planted in 1999.
Coppicing heights of 10cm, 40cm, 70cm, 100cm, and 150cm were administered. Coppicing ability, survival and die back rate were investigated.

Experiment progress:
Weeding by ripping was carried out with tractor between the trees because of labour shortage, which encouraged the formation of ridges since catchment structures were not installed. Down slope surface run-off encouraged erosion on the plot.
Because of the above reasons stagnation in tree growth was evident after about 2years.

Future plan:
A new test area should be established since the trial is relevant. Constraints that hindered continuation of the earlier investigation should also be tackled.

Attached materials :

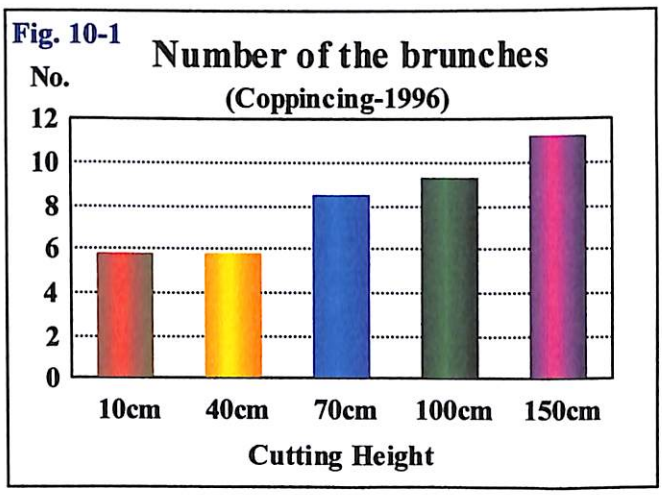
Coppicing

It is known that *Senna siamea*, *Eucalyptus spp.* and others which have been planted in the Pilot Forest can coppice well. Coppicing is most effective, especially for fuelwood forest establishment because trees can be used after a relatively short rotation and in a cost effective way.
The experiment plot was established to determine the optimal coppicing height. The trial was established in 1999 on a *Senna siamea* plot planted in 1996.
Coppicing heights of 10cm, 40cm, 70cm, 100cm, and 150cm were administered. Coppicing ability, survival and die back rate were investigated from June 1999 to June 2000.

1) Number of coppicing

This graph shows average number of coppices in each cutting height at June 2000. It is 5.8 in the 10cm plot which is the fewest, 8.4~9.3 in the 40~100cm plots and 11.3 in the 150cm plot which is the most. The same tendency was observed in previous data.

Fig. 10-1



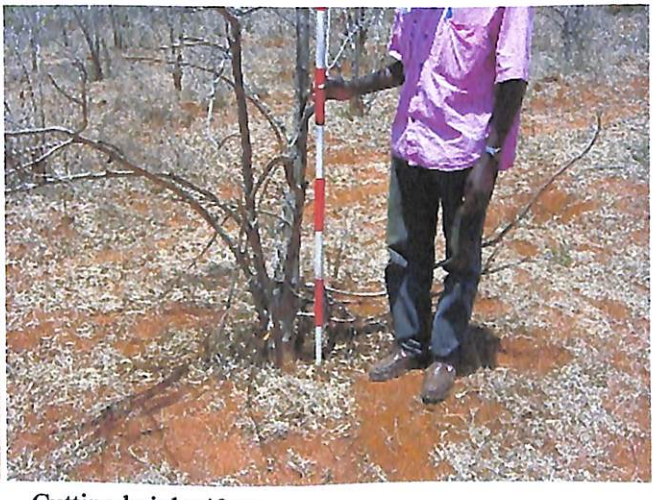
2) Survival rate

Survival rate tendency in half a year after cutting was not clear due to the variation in the plots, all plots show 70~90% survival.

3) Result

Weeding by ripping was carried out with tractor between the trees because of labour shortage, which encouraged the formation of ridges since catchment structures were not installed. It seems that the reason for few coppicing numbers in the 10cm plot was due to the influence of mechanical weeding at the lower level. Coppicing could be an effective method of regeneration in fuelwood forest establishment because it was observed that above 70% of the trees had more than 8 branches as new coppices. New experiment plot should be established for further evaluation of biomass, utilization and management of coppices as a result of thinning.

Cutting height 10cm



Cutting height 40cm

Cutting height 70cm

Cutting height 100cm

Cutting height 150cm

Technical result of the Pilot Forest

P.O	1.1.1.4	Trial	Intercropping	
Compartment			Map No.	④⑤
Species	*Senna siamea, Melia volkensii*		Area	0.41 ha
Year Planted	2000, 2001		Period	Nov. 2000 ~
Additional				
Responsible persons	Samuel Auka			

Purpose of the Trial:

To study the effect of intercropping on growth and survival of *Senna siamea.* Intercropping (agro-forestry) in ASALs, if successful, can greatly influence the establishment of farm forests by farmers because it ensures optimal labour use by spreading the risks of crop failure over other plants.

Method of the Trial:

A trial plot was established in 2000,November and planted with *Senna siamea*. In each of the plots, 25 trees were planted. Intercropping with maize and beans was later done at different densities ranging from 25% to 75%. The control plot was only slash weeded. Measurements on tree growth, survival and crop harvest were recorded.

Another test area planted with *Melia volkensii* was established in November, 2001.

Experiment progress:

After planting was done in November 2000 the harvesting of crops and tree measurement were done in January 2001. There was no big difference in amount of both crops between 50% and 75% plots but this amount was higher than that of 25% plot.

The growth of tree was better in 25% plot and 50% plot, as compared to 0% and 75% plots

From the above result, intercropping with *Senna siamea* can be recommended at 50% density for optimal crop output.

It is also clear that intercropping encourages frequent weeding to be done and as a result trees also benefit as compared to slash weeding where competition is high and therefore tree performance is affected.

Future plan:

The trial should be done with other tree species as well because the influence (relation between crops and tree water uptake and growth pattern) requires investigation for several years and procedure on how to continue need discussion.

Attached materials :

Intercropping

Intercropping (agro-forestry) in ASALs, if successful, can greatly influence the establishment of farm forests by farmers because it ensures optimal labour use by spreading the risks of crop failure over other plants.

The experiment plots were established in 2000 (*Senna siamea*) and 2001 (*Melia volkensii*), to verify the possibility of intercropping The experiment area which was established in 2001 had control plots (C0%) with no trees but were completely weeded and fully intercropped..

1) Tree growth

Tree growth in 75% plot was lower than other plots at first year, but it recovered at second year in the experiment area that was established in 2000. Average tree height in all intercropping plots was 7m at 1 year and 9 months after planting (August 2002). Tree growth in slashing is lower than in other cultivated plots, tree height was 4.4m during same time. This trend is similar for diameter.

The difference of tree growth between all planted plots was not significant. Average tree height was 2.5m; Dgl was 4.6cm 9 months after planting.

Fig. 11-1 Layout of Intercropping-2000

13 C25%	14 C0%	15 C50%	16 C75%
17 C0%	18 C75%	19 C25%	20 C50%
21 C25%	22 C50%	23 C0%	24 C75%

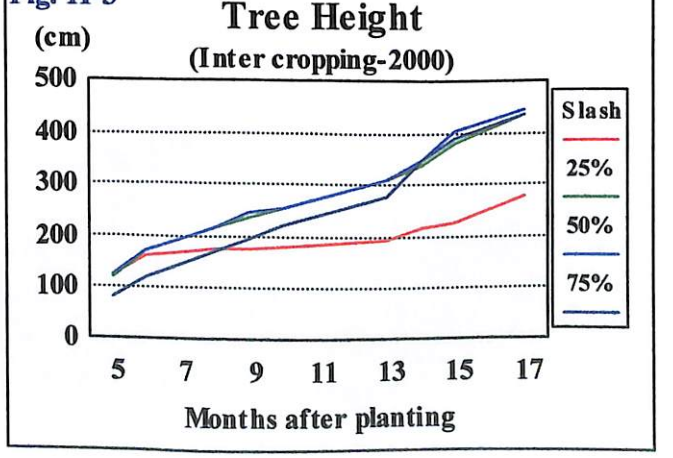
Fig. 11-2 Layout of Intercropping-2001

1 C25%	2 C100%	3 C50%	4 C0%	5 C75%
6 C50%	7 C75%	8 C100%	9 C25%	10 C0%
11 C0%	12 C25%	13 C75%	14 C100%	15 C50%
16 C100%	17 C50%	18 C0%	19 C75%	20 C25%
21 C75%	22 C0%	23 C25%	24 C50%	25 C100%

2) Crop harvest and biomass

The graphs show the amount of harvested maize and beans per unit area in 2001 and 2002 in the experiment plot established in 2000. The amount of harvested grain of both crops in C50% plot was more than in C25% plot. But in the C75% plot the amount is same or less than in the C50% plot in both years respectively.

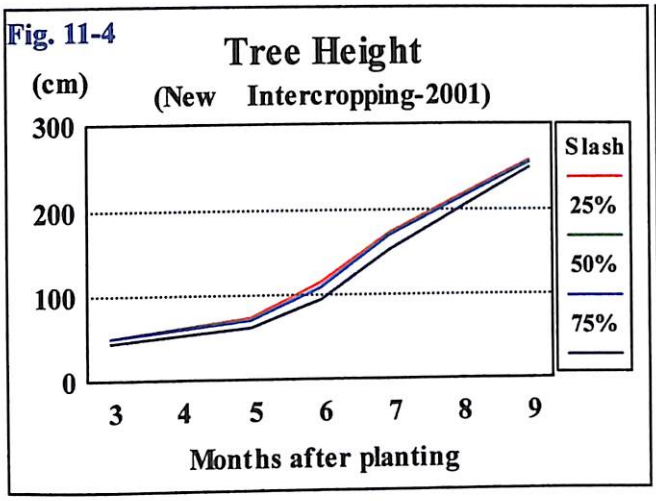
Fig. 11-3



Crop yield in the control plot (cultivated area without trees in the experiment area established in 2001) were compared with the other intercropped plots. The weeding was delayed in the experiment area due to much rain in long rain period 2002(October, 2001 ~ January 2002). Total amount of the harvest of both crops are few, but tendency was similar as in the 2000 experiment. Amount of crop yield in

control plots was 2 times higher than of 50% plots.

Fig. 11-4



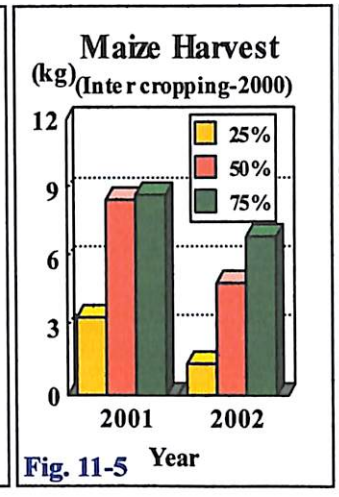


Fig. 11-5

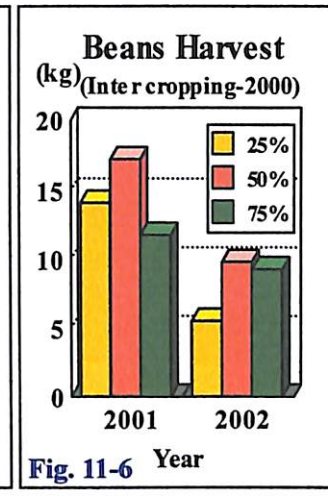


Fig. 11-6

3) Conclusion

The importance of intercropping in ASALs has been proved, tree growth performance in intercropping area was better than slashing area without influence of cultivation. Amount of harvested crops per unit area in 50% plots is same or more than in 25% plots after two seasons respectively. The 75% plots should have higher competition between trees and crops as amount of harvest in 75% plots is less than 50% plots.

Fig. 11-7

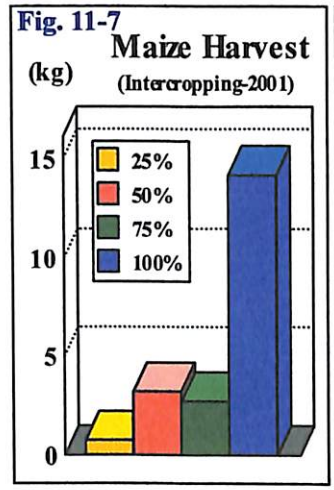
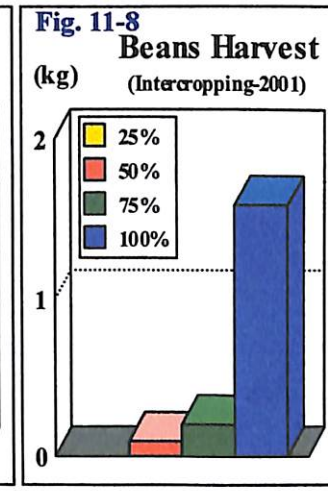


Fig. 11-8



It has been observed that intercropping does not influence tree growth, tree growth was better than slashing plots on Tiva Pilot Forest which has small amount of rainfall in Kitui district. It is very good result that maize and beans could be harvested that was not expected. Possibility of Agro-forestry in ASALs has been shown as amount of crop harvesting. The farmers who have low motivation for tree planting due to low economic incentive will be influenced by these results.

View of the 2000-experiment

View of the 2001-experiment

View of the 2000-experiment

2000-experiment with crop (*S. siamea*)

View of the 2001-experiment

2001-experiment with crop (*M. volkensii*)

M. volkensii (10 months after planting)

(Grain measurement)

Technical result of the Pilot Forest

P.O	1.1.1.4	Trial	Grass Mulching		
Compartment				Map No.	④
Species	*Senna siamea*			Area	0.39 ha
Year Planted	2000			Period	Nov. 2000 ~
Additional					
Responsible persons	Samuel Auka				

Purpose of the Trial:

The purpose is to verify the findings of a previous trial where mulching was done using two different materials. But the location of site was limited by space hence data collected became unreliable. Adoption of the technology was made difficult because of the type of materials used as mulch. Apart from the fact that acquisition of murram and sand is difficult, farmers' willingness to introduce these kind of mulching materials onto their agricultural woodland was also a cause for concern. In this regard it is believed that by incorporating the use of readily available material as mulch and by testing on a larger scale, the resultant information will be more useful and applicable to the target farmers.

The effect of overhead leaves on mulching is explained in the heat interception effect measurement test area (sun- heat trial).

Method of the Trial:

The trial was established in November 2000 on a plot that had been completely weeded and W-shaped catchments installed. Mulch diameter was set at three different levels:- 13%, 25%, 50% and a control with a thickness of 10cm in all levels. Dry grass was used as mulching material and would be replaced each time clear weeding and catchment repair was done.

Tree performance (height, diameter and survival) was investigated once every three months.

Experiment progress:

During the initial stage of establishment sawdust was used as mulching material due to shortage of dry grass. Because of this, data collected during the first one year may not give anticipated result. It also proved difficult to follow the planned prescription because every time weeding was done, repair of catchments and mulching had to be redone. The time interval between completion of weeding and re-mulching could at times be as long as two weeks.

The above factors have been considered in the analysis by Prof. Yahata (attached)

Future plan:

For effective and accurate trial establishment, any mulching materials (dry leaves, grasses) to be used should be acquired early enough. Removal of lower branches during the second year of establishment could be necessary to avoid disturbance of mulch during windy days.

Attached materials :

Grass mulching

The trial was established in November 2000 on a plot that had been completely weeded and W-shaped catchments installed. Mulch diameter was set at three different levels:- 13%, 25%, 50% and a control with a thickness of 10cm in all levels. Dry grass was used as mulching material and would be replaced each time clear weeding and catchment repair was done.
Tree performance (height, diameter and survival) was assessed once every three months since 3 months after planting.

Fig. 12-1

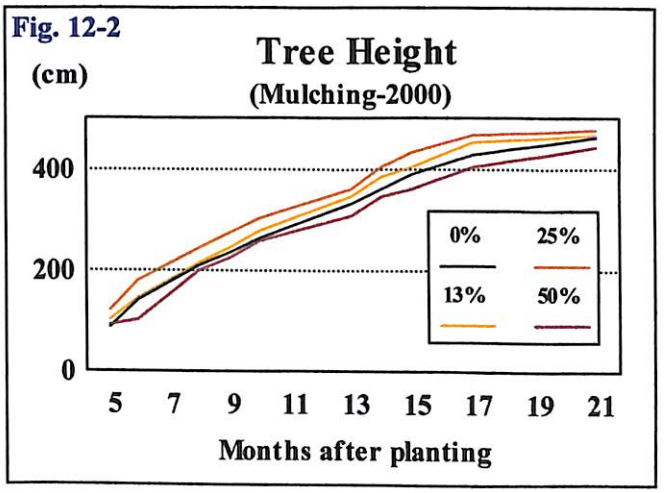
Layout of Mulching-2000

1 M50%	2 M13%	3 M0%	4 M25%
5 M0%	6 M50%	7 M13%	8 M25%
9 M50%	10 M0%	11 M25%	12 M13%

1) Tree growth

The graph shows that tree height growth in the each cover rate, All plots showed almost same growth, 4.5~4.8m as at 1 year and 9 months after planting (August 2002). No significant difference was observed between the treatments. Tree diameter (Dgl) growth showed same tendency as tree height, 8.4~8.7cm during the same period.

Fig. 12-2



2) Conclusion

The effect of mulching was not influenced by area covered by mulch. Due to late weeding the catchment structures could not be repaired in time. The catchment banks were also low due to the sandy nature of the plot. It seems that the experiment result has been influenced by problems of management of the experiment therefore the effect of mulching is not very clear.

Experiment plot

Grass mulching

Technical result of the Pilot Forest

P.O	1.1.1.4	Trial	Contour planting	
Compartment			Map No.	⑥
Species	*Senna siamea, Melia volkensii*		Area	0.95 ha
Year Planted	2001		Period	Nov. 2000 ~
Additional				
Responsible persons	Samuel Auka			

Purpose of the Trial:
To observe the effect of different catchment structures on tree growth and their ability to control soil erosion.

Method of the Trial:
The plot is divided equally into 4 parts, and in 2 plots W- shaped water catchments and a terrace plot installed alternately. *Melia volkensii* and *Senna Siamea* with 4m×4m spacing were planted in all the area. Where *Melia* was planted W-shaped catchments were constructed on upper part leaving the trees about 0.5m outside the lower tip of catchment bottom.

Experiment progress:
The experiment plot was established in November 2001 and further observation will be necessary from now on.

Future plan:
The experiment plot was established in November 2001 and further observation should continue.

Attached materials :

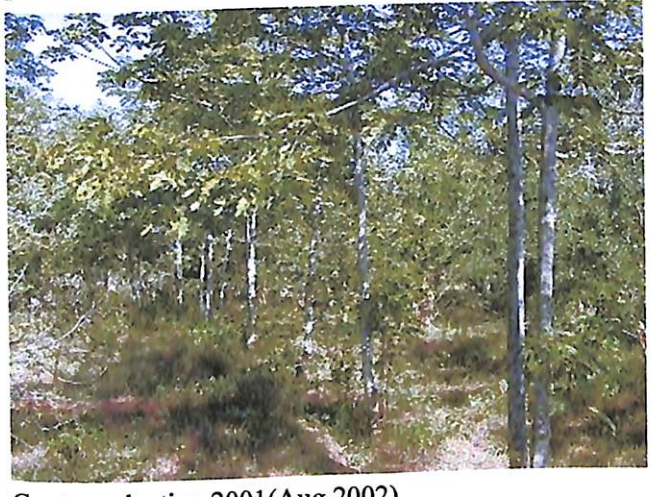
Contour planting

Much rainwater is soaked in the soil and reducing moisture competition with the weeds are the most important things for tree planting in Asals. The contour planting plot which was planted in 1994 by SFTP showed better performance in survival rate and tree growth than all other plots. It seems the trees have grown well due to the contour structures that prevented water run off and have improved water infiltration into the soil.

Even though construction of contour requires high capital and labour input, farmers who construct contours on their farms are increasing around Kitui area. Therefore the experiment plot was established in November 2001 to verify effect of contour planting and for demonstration to farmers.

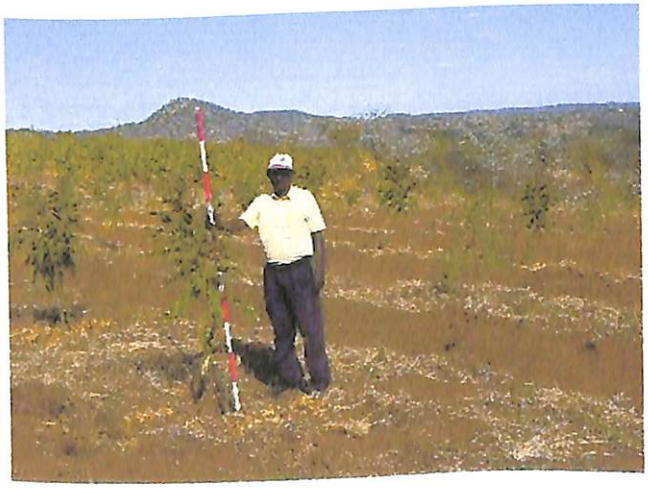
The experiment area has 4 plots which have 2 contour plots and 2 W-shaped micro catchment plots, planted alternately with *Senna siamea* and *Melia volkensii* under 4m×4m spacing. Tree growth data has been collected since 3 months after planting.

Melia volkensii was initially affected by weed suppression due to delayed weeding during the long rain season of 2001(Nov. 2001 ~ Jan. 2002). However both tree species are growing smoothly at present.



Contour planting 2001(Aug.2002)

Contour planting 2001(Aug.2002)



9 month after planting

Contour Repairing

Technical result of the Pilot Forest

P.O	1.1.1.4	Trial	Trenching		
Compartment				Map No.	⑦
Species	*Melia volkensii*			Area	0.22 ha
Year Planted	2001			Period	Nov. 2000 ~
Additional					
Responsible persons	Samuel Auka				

Purpose of the Trial:
To investigate possibility of tree establishment by controlling competition through removal of side roots by trenching.

Method of the Trial:
Three different square trench depths of 30cm, 50cm and 70cm were dug. In each of the plots 9 seedlings of *Melia volkensii* planted about 0.5m outside the lower part of W-shaped catchments. Tree performance, growth/survival rates will be monitored.

Experiment progress:
The experiment plot was established in November 2001 and further observation will be necessary from now on.

Future plan:
The experiment plot was established in November 2001 and further observation will be necessary from now on.

Attached materials :

Technical result of the Pilot Forest

P.O	1.1.1.4	Trial	Establishment of *M. volkensii* & *D. melanoxylon* plots	
Compartment			Map No.	⑧⑨⑩⑪
Species	*M. volkensii, D. melanoxylon*		Area	0.48 ha
Year Planted	2001		Period	Nov. 2001 ~
Additional				
Responsible persons	Samuel Auka			

Purpose of the Trial:
To develop and promote establishment of utility tree species in arid and semi arid areas.

Method of the Trial:
Establish annual plantation plots according to KEFRI Tiva management plan. The plan aims at establishing 7.0, 3.0 and 2.0 ha of *Melia volkensii*, *Dalbergia melanoxylon* and *Terminalia brownii* respectively.

Experiment progress:
In the year 2001 about 7.5ha of *Melia volkensii* and about 1.0ha of *Dalbergia melanoxylon* was planted.

Future plan:
The management plan will be implemented over a 10 year period.

Attached materials :

Technical result of the Pilot Forest

P.O	1.1.4	Trial	Establishment of Wild fruits demonstration orchard	
Compartment			Map No.	③
Species	12 species		Area	1.04 ha
Year Planted	1999		Period	Nov. 1999 ~
Additional				
Responsible persons	Samuel Auka			

Purpose of the Trial:
To establish an indigenous fruit tree demo plot for domestication purposes.

Method of the Trial:
The species were planted on a 1.0 ha plot with a spacing of 8m x8m. Land preparation was done by dozer bush clearing and ripping.

Experiment progress:
A demonstration plot was established in 1999 consisting of 12 different species.

Future plan:
The management plan will be implemented over a 10 year period.

Attached materials :

Technical result of the Pilot Forest

P.O	1.1.5.1	Trial	Meteorological data collection		
Compartment	Weeding plot, 1999			Map No.	①
Species				Area	
Year Planted				Period	
Additional					
Responsible persons	Samuel Auka				

Purpose of the Trial:
To monitor weather parameters such as rainfall amount, relative humidity, temperature, humidity and other basic data and relate the same to tree performance.

Method of the Trial:
Data collection is by weather observation devices installed in 1999 on weeding experiment plot of the same year. Data logger connected to each sensor, through electric signal, records information automatically every thirty minutes. Recorded data is retrieved regularly by the personal computer.

Experiment progress:
Collection of data is on going.

Future plan:
The activity will continue

Attached materials :

Technical result of the Pilot Forest

P.O	1.1.5.2	Trial	Collection of references		
Compartment				Map No.	
Species				Area	
Year Planted				Period	
Additional					
Responsible persons	Samuel Auka				

Purpose of the Trial:
To collect reference materials related to forestry technology in arid and semi arid areas.

Method of the Trial:
Collection of materials such as books and booklets, journals, reports etc from other institutions and organizations

Experiment progress:
Different types of books, journals, and assorted reference materials were collected.

Future plan:
Collection of reference materials continues

Attached materials :
List of reference materials

Technical result of the Pilot Forest

P.O	1.1.5.3	Trial	Management of experimental plot and road network	
Compartment			Map No.	
Species			Area	
Year Planted			Period	
Additional				
Responsible persons	Samuel Auka			

Purpose of the Trial:
To ease accessibility into the Pilot forest for management purposes.
To update plantation plot records.

Method of the Trial:
Maintenance of old forest roads by undertaking roadside bush and drainage clearance. Creation of access roads leading into new plantation plots. Labeling roads and plots for ease of identification. Establish and adhere to prescribed plantation plot management plans. Frequent and routine forest road maintenance will be undertaken to ensure easy access into plantations for management and patrolling activities.

Experiment progress:
Preparation of record of all plantation plots is currently underway. The final draft of KEFRI management plan for Tiva has just been released.
Minor repair works were done on a 14.5km stretch of roads. The western side of project boundary was demarcated and clear marked by dozer.

Future plan:
Implementation will be done according to Tiva management plan.

Attached materials :

Technical result of the Pilot Forest

P.O	1.1.5.6	Trial	Protection against human and animal damage	
Compartment			Map No.	
Species			Area	
Year Planted			Period	
Additional				
Responsible persons	Samuel Auka			

Purpose of the Trial:
To minimize incidences of illegal exploitation of forest and other products within the pilot forest. Sensitization of neighbouring community on the need for environmental conservation and sustainable utilization of forest resources.

Method of the Trial:
Involves erection of physical barriers (dead wood, barbed wire fences or road barriers) for prevention of encroachment by humans or animals. Patrolling mainly during daytime was also done. Holding public barazas with surrounding communities.

Experiment progress:
Four forest road barriers were erected to control movement within the pilot forest. Barbed wire fences were also used in the newly established plots. KEFRI employees were deployed as patrolmen and security. A number of public barazas were held with the neighbouring community/leaders.

Future plan:
The pilot forest continues to report cases of illegal forest product exploitation as pressure for wood resources rise due to population increase. The future focus should be on community sensitization through education by conducting open field days, public barazas and guided visits to the pilot forest.

Attached materials :

Technical result of the Pilot Forest

P.O	1.1.5.7	Trial	Study on cost analysis		
Compartment				Map No.	
Species				Area	
Year Planted				Period	
Additional					
Responsible persons	Samuel Auka				

Purpose of the Trial:

The working process of each main activity was surveyed in order to acquire more knowledge on work output and labour cost effectiveness.

Method of the Trial:

The method of investigation involved collection of data by means of a daily work sheet filled in during and after working periods. More often the entries were made without direct knowledge of the concerned people (workers) to avoid bias.

Experiment progress:

Complete weeding

Man days / ha.....56 man days

Area / person.....0.02 ha

Water catchment (W shape, thickness 15cm, 4m by 4 m)

Man days / catchment.....0.1 man days

Catchment / person.....7 catchments

Digging holes (Diameter=45cm, Depth=45cm)

Man days / hole.....0.1 man days

Holes / person.....15 holes

Planting

Area / person.....0.02 ha

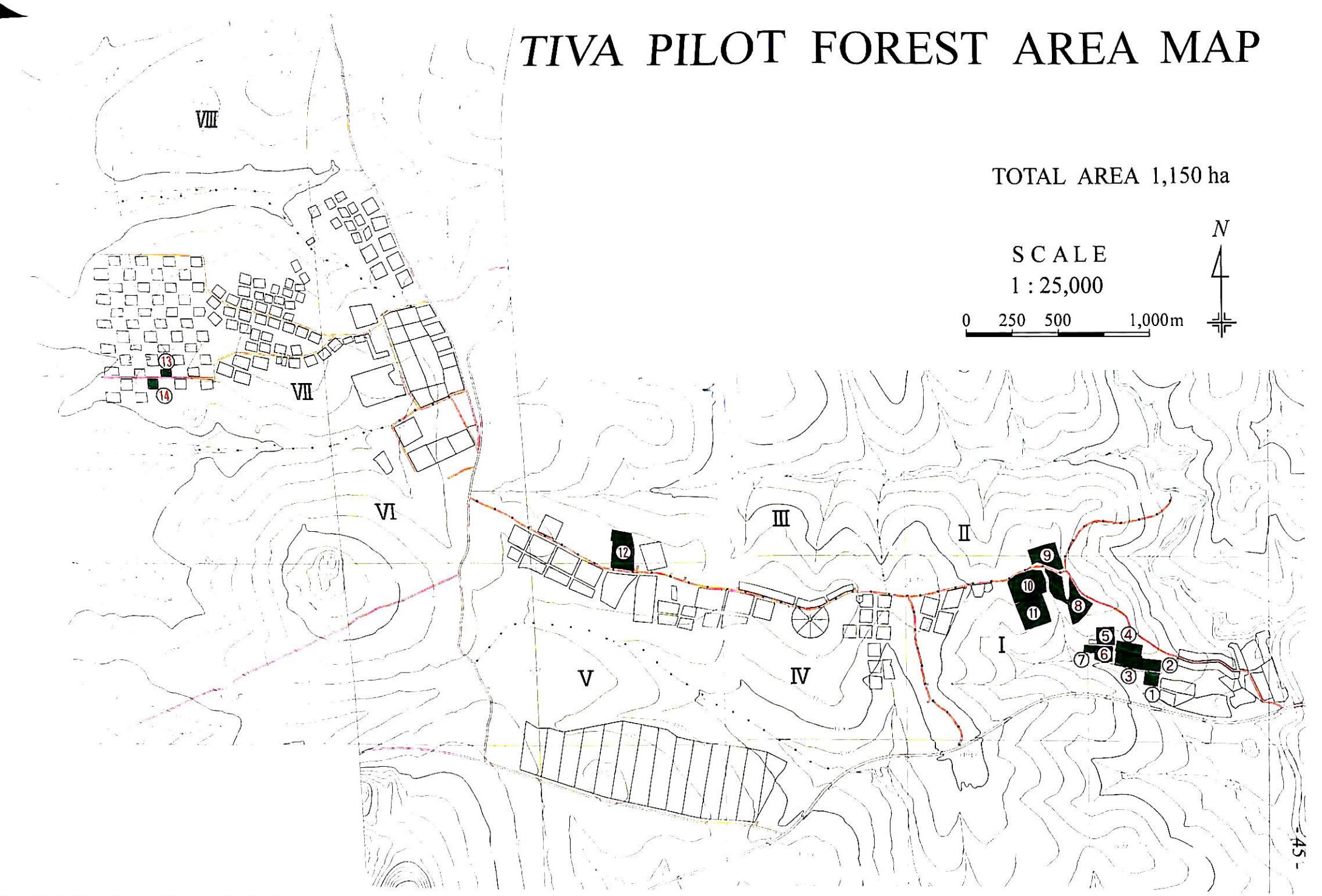
Seedlings / person.....48 seedlings

Future plan:

Investigation on work output study continued for two years between 1998- 1999. The above data was compiled during the period of investigation. Any further investigation on the same may not provide new information and therefore the above data could be useful as reference in future.

Attached materials :

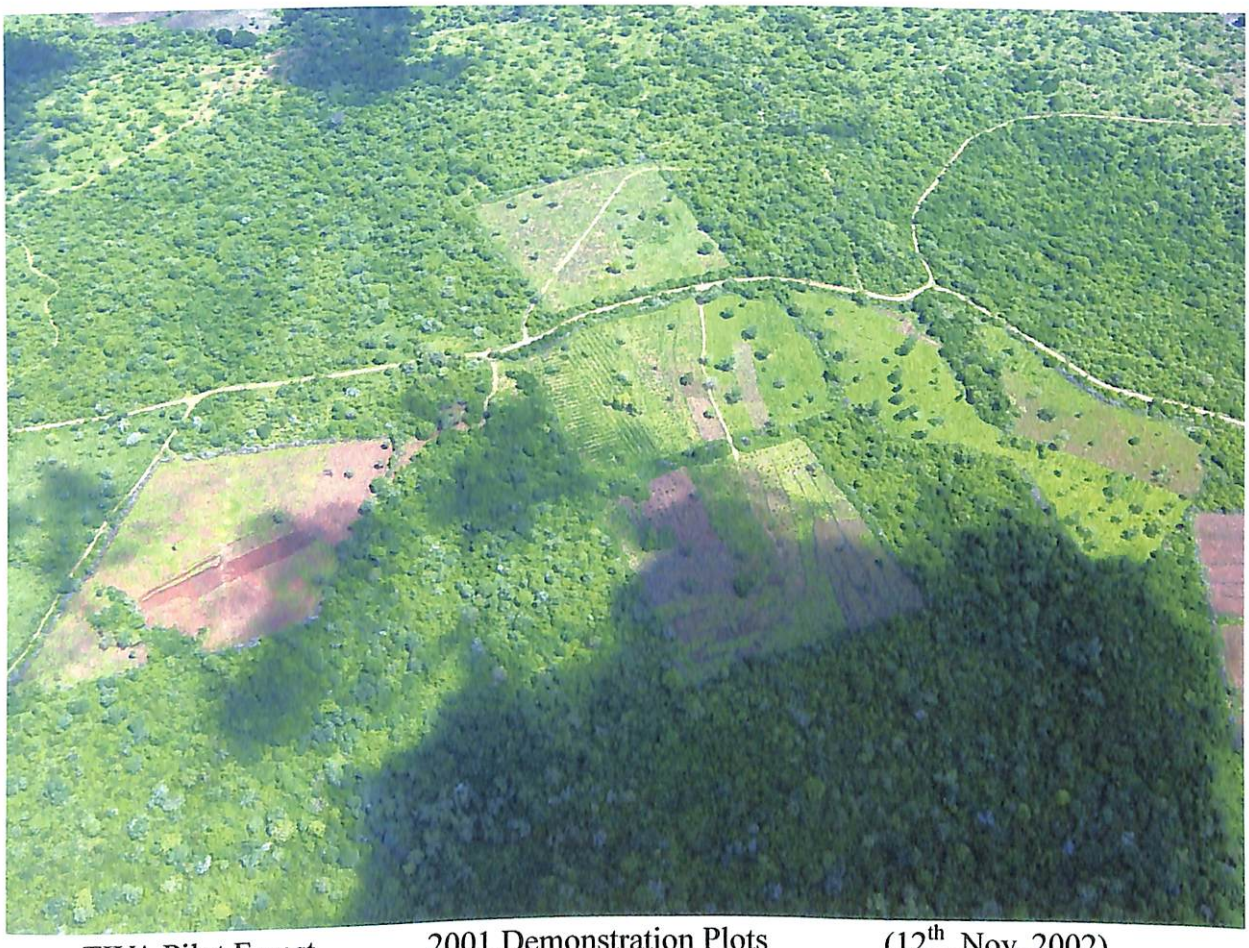
TIVA PILOT FOREST AREA MAP



TIVA Pilot Forest Tower site (12th. Nov. 2002)

TIVA Pilot Forest Old Yahata Experiments (12th. Nov. 2002)

TIVA Pilot Forest New Yahata Experiments (12th. Nov. 2002)



TIVA Pilot Forest 2001 Demonstration Plots (12th. Nov. 2002)