AN OBSERVATION ON THE PILOT FOREST ACTIVITIES

HIROJI OKABE

20 November 1992

AN OBSERVATION ON THE PILOT FOREST ACTIVITIES

HIROJI OKABE

20 November 1992

P R E F A C E

This booket is the result of species screening programme that was instituted in Kwa-vonza location in Kitui District under Kenya/Japan Social Forestry Training Project. Todate the project has established about 340 ha of trial plantations, of different promising dryland species under an array of best bet tree planting technique, and management practices.

The author has been involved in the implementation of the project as a Chief Adviser, from September 1989 to date. This opportunity has enabled him to undertake a careful synthesis of results of different investigations on crop establishment and promising management protocols. Tree planting in the subhumid areas is both a challenging and daunting task. Results of this work will undoubtedly stimulate and enrich the growing interest in afforestation of ASAL and conservation of ASALs plant genetic resources.

I am confident that the excellent work initiated during phase 1 of the Social Forestry Project, will be maintained as the technology base continues to be expanded. Admittedly more species from local and exotic sources must be recruited into future species evaluation programmes to enable the study to capture an acceptable range of options and capacity to meet the ever increasing needs for tree planting and conservation of biodiversity.

J. A. Odera
DIRECTOR KEFRI

CONTENTS

SUMMARY

The Kenya/Japan Social Forestry Training Project is composed of two sub-projects: The Social Forestry Training and The Pilot Forest Schemes. The Pilot Forest Scheme has been implemented since November 1986, under the Special Measure Fund from the Government of Japan through Japan International Co-operation Agency (JICA). The project has established about 300 ha of trial plantations from 1986 to 1991. The aims of the Pilot Forest activities are to evaluate suitable tree species for planting in the semi-arid area in Kitui district and to develop improved tree planting techniques for satisfactory survival and crop development in the area. It is also expected that the results of the trial plantation will act as a model and growth point for social forestry development in the semi-arid land areas.

This booklet describes land preparation, planting hole size, water catchment method, weeding, mulching, etc. as the Pilot Forest activities. The author chose some species which would be planted in the Pilot Forest in accordance with the October 1991 data. Unfortunately, precipitation in Kwa-vonza Location has been very low in 1992, so that the planted trees have been severely damaged this limited the author from collecting sufficient data on the above mentioned species. Finally, the author describes the performances of most of the species planted in the Pilot Forest by 1989.

Although this booklet covers only those species that have been studied in the Pilot Forest Scheme, the information will not only be useful to the Pilot Forest but the result of this work will undoubtedly be beneficial to the development of tree planting in the semi-arid land areas in Kenya and elsewhere.

AN OBSERVATION ON THE PILOT FOREST ACTIVITIES

1.0 Introduction

"An Observation on the Pilot Forest Operations" written by Mr. Yoshihiko Watanabe, who was a former leader of Pilot Forest Scheme of the Kenya/Japan Social Forestry Training Project (SFTP), presents a very important account of the establishment process of the Pilot Forest activities for about 3 years. Prof. Sumihiko Asakawa, Messrs. Katsura Watanabe and Masahiko Hori independently concurred in their comments that the report presented a very important record of the Pilot Forest activities in addition to raising several important points on the Pilot Forest Management. The author contends that the report raised not only the above mentioned points, but also participatory approach to plantation establishment and conservation methods in semi-arid areas.

Drawing from Mr. Watanabe's report and the above mentioned comments, the author intends to rewrite the Pilot Forest activities using current data from the Pilot Forest in addition to those presented in February 1991. It is noteworthy that the original version of the author's comments sent the his predecessor, Mr. K. Watanabe was in Japanese at that time. Mr. K. Watanabe requested that the report be translated in English.

It is the author's intention to incorporate these observations in his final report on the overall project activities at the end of the first phase of SFTP. Then he wanted to write this booklet based on his final reports.

In brief, the author would wish to refer to the report and comments as follows:

Mr. Y. Watanabe's report as "original report", Prof. Asakawa's as "Asakawa's comments", Mr. K. Watanabe's as "Watanabe's comments" and Mr. Hori's comments as "Hori's comments". The author observes that the original report and comments written in Japanese have not yet been published.

At first, the Kenya/Japan Social Forestry Training Project was known as the Nursery Training Project. The Project was started on 26 November 1985, beginning with a two year preparatory phase, within Kenya Forestry Research Institute (KEFRI)

The Project mostly aimed to train both extension agents and farmers on nursery techniques and consisted of a Training Scheme and a Pilot Forest Scheme.

Main objectives of the Pilot Forest Scheme included, establishing of trial plantation in the Pilot Forest area located in Kwa-vonza Location/Division of Kitui District in order to develop social forestry techniques, developing nursery techniques to raise seedlings to plant in the Pilot Forest and distribute to farmers, and generating appropriate extension methods for application in semi-arid area.

As the original report dealt with establishing trial plantation in the Pilot Forest, the author is, therefore, limited to write on the same here.

The trial plantation was started in November 1986, that is six years ago. Since then, the Project has continued to carry out planting activities in an area of about 300 ha with 51 different species, including both indigenous and exotic. The Project has also been carrying out various trials and assessments on establishment and tending techniques using some of these species.

The object of the trial plantation is to develop tree planting or establishment and tending techniques that farmers would be able to adopt and use immediately in order to develop social forestry in semi-arid areas. The trial plantation activity also provided opportunity for establishing a model forest for farmers. It would not be enough to say that the establishment of several hundreds ha of forests themselves contributes to the development of social forestry, however, it would suffice to say that the techniques developed through establishing trial plantation on the Pilot Forest gives very important achievement in developing and enhancing appropriate techniques for application in semi-arid areas.

With increase in population growth, it is evident that shortage of fuelwood will be progressive in the near future. As a result, farmers, are expected to take the necessary lead and action by planting trees in their compounds, farms and grazing lands. However, it would be impossible that a farmer would be able to get fuelwood, enough to be consumed by his family from his farmland especially when he does not have large area of farmland. Therefore, the author observes that in the near future, there will be some necessity to plant trees in some County Council land, because of the shortage of land to plant trees. The author also observes that the techniques developed at the Pilot Forest will be useful in such cases and of course, for farmers' social forestry activities.

2.0 Materials and Method

2.1 Situation of Pilot Forest

The Pilot Forest is situated in Eastern Kenya and lies at latitude 1.20 (S) and at longitude 31.10 (E). The Pilot Forest is on average 1,100 m above mean sea level. Soils of the Pilot Forest site may be classified into three categories as those belonging to Acrisol, Luvisol and Vertisol, according to the FAO/UNESCO soil classification system.

The Pilot Forest receives a mean annual rainfall of 700 to 1,100 mm falling in two rainy seasons a year. Short rainy season comes in March to April, and the long one comes in October to December (Table 1). The temperatures at Tiva Nursery for past three years are shown in Table 2.

Table 1: Rainfall Record at Tiva Nursery

Monthly Total Rainfall (mm)

Month	1988	1989	1990	1991	Average
January	33.5	106.5	21.0	80.0	60.3
February	0.5	0.0	44.0	0.0	11.1
March	165.6	21.0	212.0	37.0	108.9
April	143.5	270.5	266.5	122.0	200.6
May	3.0	65.5	36.5	52.5	39.4
June	0.0	3.5	0.0	0.0	0.9
July	0.0	0.5	3.0	6.0	2.4
August	6.0	0.0	0.0	20.5	6.6
September	22.0	0.0	22.5	1.0	11.4
October	48.0	193.0	50.0	22.5	78.4
November	247.0	285.0	248.5	286.3	266.7
December	201.0	67.0	216.5	97.0	145.4
TOTAL	870.0	1013.5	1120.5	724.8	932.2

The Pilot Forest has a slight slope sparsely covered with natural and a number of tree species and other vegetation including, Acacia spp. Comiphora spp, Aspilia mossambicensis, Solanum incanum, Cynodon nlemuensis etc. The animals in the Pilot Forest area include dik-dik, and apart from the wild animals there are also domestic animals which often come and graze, they include goats, sheep and cattle. There are also inhabitation of termites in the area.

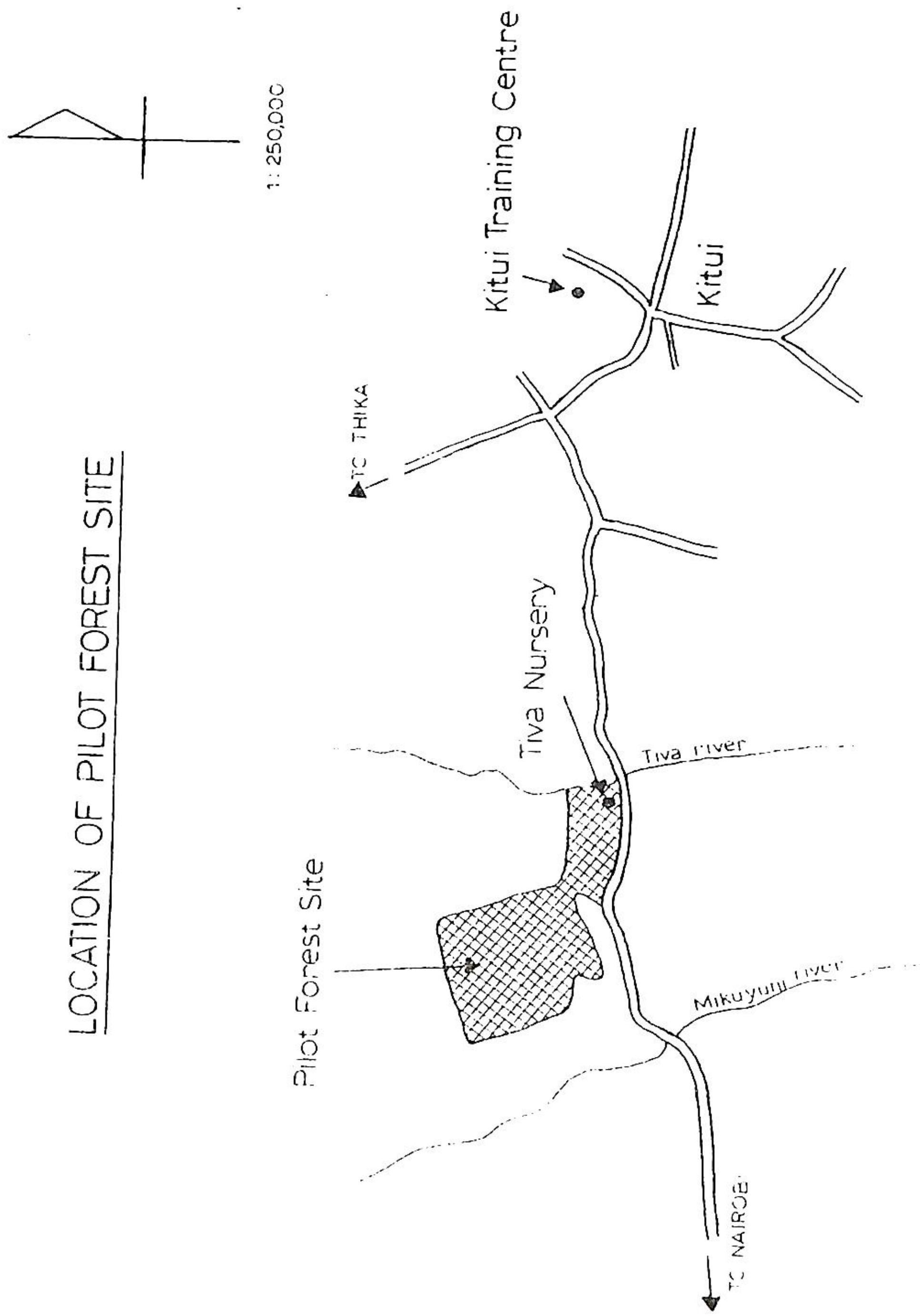

Fig. 1 Location of Pilot Forest

Table 2 Average Temperature at Tiva Nursery (Deg. C)

Month	Minimum	Maximum	Average
January	16.0	30.2	23.1
February	16.5	31.5	24.0
March	17.2	31.5	24.4
April	18.2	29.4	23.9
May	18.3	28.6	23.4
June	15.5	27.5	21.5
July	15.4	26.3	20.9
August	15.6	26.4	21.0
September	16.3	28.5	22.8
October	17.4	30.0	23.7
November	17.7	28.7	23.3
December	16.8	29.4	23.1
Average	16.7	29.1	22.9

Note: Average from 1989 to 1991.

2.2 Plantation Establishment in the Pilot Forest

Vegetation in semi-arid areas is vulnerable, once damaged it is very hard to restore the original one. Therefore, enrichment planting method is adopted in some areas like the Pilot Forest as an establishment strategy by Forest Department. The implementation is such that some useful trees which are more than 5cm in diameter in breast height are reserved, and that the slashing width should be less than 2m in case of a strip. In case the total slashing method is applied, then it should be less than 0.25 ha in site preparation works. These restrictions are enforced to enhance preservation of the local environment, however, under these restrictions, plantation establishment by enrichment method has yet to show that good results could be obtained.

In rainy seasons, especially during the months with precipitation of more than 200mm, vegetation on the ground grows up very fast, especially, Aspilia mossambicensis which grows on good soil. It seems that it will be possible to carry out total slash site preparation further into the wider area with a gentle slope to encourage these fast growing vegetation, where they are present.

However, as there are some differences in erosion between the upper and lower gradients of the land-space heavy soil erosion will tend to occur in the overgrazed land. As a result, appropriate land preparation techniques takes care of soil erosion.

2.3 Operation

Although this report deals mostly with the results of the Pilot Forest operation. it is important to note that the operations were not conducted in a scientifically designed basis. As a result the author reports on some of the operations he observed and their results. Furthermore, the author intends to elaborate on the results obtained in addition to using the original report, comments, working papers and other reports of the Pilot Forest activities.

The seedlings planted initially came from Hola Station Tree Nursery of KEFRI and Forest Department Nursery at Kitui in 1986, but from 1987 the project raised its own seedlings for subsequent plantings.

The number of species planted reached 51 species by the end of 1991. Most of them would be analyzed later to show their performance in terms of survival and growth rate. The observed items of operation are as indicated below:

2.3.1 Site Preparation

The Project carried out both "total slash" site preparations and "strip" site preparations in widths of lm, 2m, 3m and 4m leaving only useful trees of more than 5cm diameter in breast height, but trimming or cutting off some branches as a management strategy.

2.3.2 Planting Hole Size

The Project has tried to dig planting holes of sizes 65 x 65 cm, 45 x 45 cm and 25 x 25 cm in diameter and depth.

2.3.3 Water Harvesting Method

The Project tried to make different micro-catchments, particularly the Turkana method in order to determine some appropriate water harvesting methods.

2.3.4 Timing of Planting

The necessity of planting earlier in rainy season cannot be over-emphasised

2.3.5 Mulching and Spot Weeding

The Project tried to examine stone and grass mulching and spotweeding to enhance plant survival.

2.3.6 Weeding

The Project could not weed about half the plantation area planted in 1988, and within a period of one month (between 22 December 1988 and 31 January 1989), the author was able to pick up significant difference in seedling survival between the weeded and unweeded sites.

3.0 Result and Discussion

3.1 Planting Methods

3.1.1 Site Preparation

The original report recommended site preparation using total slash method but retaining some useful trees of sizeable diameters. This concurs with Prof. Asakawa's comment. Messrs. K. Watanabe and Hori had the following observations:

Thus, if the purpose of site preparation is only taken as to maintain good sunny conditions and to control competition between planted trees and weeds, bushes for moisture, then slash method and total weeding are desirable. However, it is important to consider the environmental and economic aspects of plantation establishment, some trees and shrubs are to be retained as observed by both Prof. Asakawa and Mr. Y. Watanabe.

According to survey on relationship between relative light intensity and tree growth, it has been clearly observed that there are some positive correlation between the two elements in Mimosaceae species, however, this correlation is not significant in Caesalpinaceae species, moreover, in Croton megalocarpus, there is a negative correlation.

On the assumption that the purpose of enrichment method of plantation establishment is expansion of production of wood, it may imply that there is no reason to establish pure forest stand. Though the Project is considering the possibility of enrichment method in the Pilot Forest, it might be possible to do so with some species, which should be determined through the Pilot Forest activities. From a social forest point of view, the most important item is not necessarily to establish pure forest which one is proud of, but to have a multipurpose forest from which farmers can get poles, fuelwood, fodder and so on. Consequently it seems that the site preparation method which is desirable to the environment should not only be a good method, but also one that will retain many useful trees as possible in the plantation site, if they would not have some negative effects on the growth of planted trees, and other trees. Bushes and weeds should be slashed and in some areas, this could be 1 or 2 ha.

Indeed, there are so many trees in the Pilot Forest. But if that was true everywhere, there would be no need to plant trees or particularly by enrichment method. The issue on how to apply this point in the field has severally been subject of discussion between Mr. Y. Watanabe and the author. It seems that Commiphora spp. which have some negative effects on planted trees, should be cut to maintain good sunny conditions. According to Hori's comment and observation of this year's results, it is desirable to leave trees in planted area to enhance survival during the early stages of establishment, especially in severe drought. However, in the case of shade intolerant tree species, the idea should be modified. The appropriate site preparation method should then be decided by the tree species to be planted.

The other issue is undergrowth. In good soil areas of the Pilot Forest, Aspilia mossambicensis grows luxuriantly, and the species grows very fast. After slashing it will grow to nearly 1m in height in five weeks!,

and to about 3m if not slashed for a long time. This means that if site preparation could be done by strip method with 1 or 2m width, planted trees would be covered by A. mossambicensis soon after establishment. Therefore, in those cases, strip width should be more than 3m. It seems that total slashing method of site preparation should be done within small areas, if the area is not sloping, or strip slashing with more than 3m, since erosion would be controlled by bush.

3.1.2 Planting hole size

The original report indicates that there were positive correlations between hole sizes and survival rates or heights of planted trees in planting hole size experiment area 1988. Nevertheless, Watanabe's comment observed the contention as exaggerated while Asakawa expressed some concern over the same in his conclusion. Indeed, trees planted in the experimental plot in 1988, validated the conclusion was correct at the young stage. However, it seemed, as Asakawa's comment mentioned, that the effect of hole size did not continue for a long period.

The original report indicated that since the planting hole sizes in 1989 were dug mostly 65x65 cm in diameter and depth, it would result in good performance. Although, site preparation had been done by strip slash method with 1 m slashed and 2 m none slashed in 1988, and 2 m slashed and 1 m none slashed in 1989 respectively, not to mention the differences in precipitation, the author did observe and ascertained the effects of hole size on 5 major species. Table 3 shows survival rate of the mentioned species.

Table 3: Mean survival rate of major species (Unit: %)

Species	Planted 1988				Planted 1989	
	2/89	7/89	10/90	10/91	11/90	10/91
Acacia polyacantha	95.4	57.4	-	48.0	89.8	73.5
Cassia spectabilis	78.8	73.3	60.2	56.8	95.1	92.4
Croton megalocarpus	98.4	90.4	84.9	84.9	96.2	86.6
Prosopis juliflora	95.8	83.0	44.6	40.3	20.5	10.2
Tamarindus indica	95.5	86.6	58.5	54.2	89.2	73.7

Note: Planting hole size listed was 45x45 cm in 1988, 65x65 cm in 1989.
- Omitted because of abnormal figure

Although survival survey was done 8 months after planting in the 1988 plantation, and 11 months after planting in the 1989 plantation, survival rate in 1989 plantation areas are better than of 1988. Comparing those plantation sites two years later after planting, survival rates of Acacia polyacantha, Cassia spectabilis and Tamarindus indica planted in 1989 was better than that of 1988. Factors which will affect the survival rates are not only planting hole size, but also precipitation, soil condition, site preparation method, seedlings, technique of planting, weeding and so on. Therefore, the survival rate in the 1989 plantation cannot be attributed to planting hole size only.

There are three types of planting hole sizes planted in 1989. The survival rates are shown in table 4. The survey carried out in 1990 indicated that there was no relationship between planting hole size and survival rate on Cassia spectabilis. The species T. indica, A. polyacantha and C. megalocarpus showed the best survival rate in planting hole sizes of 45 x 45 cm and 65 x 65 cm. However, Prosopis juliflora had the lowest survival rate in 65x65 cm planting hole size, in November 1990. There is a probability that there were some strong factors effecting such results.

Table 4: Survival rate by planting hole size Unit (%)

Species	November 1990			October 1991		
Size	25	45	65	25	45	65
Acacia polyacantha	60.9	95.5	89.3	17.4	80.5	73.5
Cassia spectabilis	95.7	94.2	95.1	73.8	90.1	92.4
Croton megalocarpus	78.0	98.0	95.6	65.5	86.5	86.6
Prosopis juliflora	38.1	39.0	20.5	13.0	8.0	10.2
Tamarindus indica	71.0	69.0	89.2	40.0	27.0	73.7

According to a survey carried out in October 1991, Acacia polyacantha showed the best survival rate in 45x45 cm planting hole size, with Cassia spectabilis and Croton megalocarpus there were no significant differences between 65x65 cm and 45x45 cm planting hole size. With Tamarindus indica, many trees died between November 1990 and October 1991, it seemed the cause was some other related factors, although the species showed the best survival rate in 65x65 cm planting hole size.

In Watanabe's comment, the economic aspects of the respective planting hole sizes and area weeded was an important consideration. It is not worthy that one worker can pit 20 holes per day of 45x45 cm, 10 holes per day of 65x65 cm, while less than 25 workers can weed one ha of strip weeding. Table 5 shows average tree height for both hole size 45x45 cm and 65x65 cm in an experiment area planted in 1988. When considering the fast growing species, Aspilia mossambicensis, would realise maximum average tree height of 2 m. Weeding should be done twice a year. However, this could be reduced to weeding once in Croton megalocarpus, and twice in Cassia spectabilis.

Table 5: Average tree height (Unit: cm)

Hole size	45x45 cm		65x65cm	
	7/1989	8/1990	7/1989	8/1990
Cassia spectabilis	155	202	199	290
Croton megalocarpus	138	201	165	235

Supposing that a plantation of Cassia spectabilis has a stocking of 1,000 seedlings per ha, then it may not be economical to plant in hole of size 65x65 cm planting hole size. However, if the stocking is 800 seedlings per ha, then it may be relatively economical and comparative to planting in 45x45 cm hole size. This result was got from the experimental plot whose soil condition was very good and weeded several times per year, so the result could not be generalized. However, this result is considered to show a certain trend.

As in Asakawa's comments the above results indicate that the 45x45 cm planting hole size was more appropriate. Hence, farmers want a few trees in their compounds, then they could adopt the big hole size. However, the author observes that there are limits on planting hole size.

3.1.3 Water catchment

The original report indicated this operation had no effect on tree survival rates, while Hori's comment stated that it was too early to make such remarks. Table 6 shows survival rate surveyed in October 1990 for a plantation planted in October 1989 using Turkana and micro-catchment methods. Although experimental plots of the Turkana method are only about 0.05 ha, the result is significant. A comparison of the survival rates in 45x45 cm hole size and two types of water catchment, after a year of planting, indicates that there were few differences in survival rate except for Prosopis juliflora. And 2 years later, the survival rates of P. juliflora and Tamarindus indica in the respective water-catchment methods indicated some good results. The survival rates of Acacia polyacantha, Cassia spectabilis and Croton megalocarpus planted in 45x45 cm hole size were of the same level in Turkana method, but, not as good in the micro-catchment method.

Table 6: Effects of water catchment method on survival rates (%)

Species	November 1990			October 1991		
	45x45	Turk.	Micr.	45x45	Turk.	Mic.
Acacia polyacantha	95.5	95.0	71.8	80.5	90.0	40.0
Cassia spectabilis	94.2	95.0	100.0	91.0	80.0	55.6
Croton megalocarpus	98.0	95.0	92.9	86.5	90.0	73.8
Prosopis juliflora	39.0	61.0	61.0	8.0	45.0	17.1
Tamarindus indica	69.0	75.0	77.5	27.0	45.0	65.5

Note 1 45x45 : Planted trees in hole size of 45x45 cm
2 Turk : Turkana method
3 Micr. : Microcatchment method

3.1.4 Timing of Planting

In order to overcome drought by tree seedlings after planting in semi-arid areas, it is very important to let root system develop as much as possible after planting during the time when the soil contains some moisture. Therefore, seedlings should be planted after enough rain and as early as possible. According to Mr. Niino's survey, roots of Prosopis juliflora reached 180 cm depth in the soil, while those of Cassia siamea reached 150 cm one year after planting. Tap roots of Acacia nilotica and Acacia tortilis reached about 60 cm depth in the soil within 30 days after planting in some experiments, Asakawa et al, (1990). It therefore, seems that if some tree seedlings are to be planted in the middle of November and there would be enough rainfall after planting, the tap root would reach at least 150 cm depth in a year if they don't die. However that would depend on soil condition. Nevertheless, there may be no question of planting seedlings as early as possible because of the erratic nature of rainfall and soil conditions in such areas.

3.2 Tending

3.2.1 Grass and stone mulching

There are two mulching methods adopted at the site, however, as Messrs. K. Watanabe, Y. Watanabe, Hori and Prof. Asakawa could not have any guidelines leading to substantive results about these methods when they wrote the original report or comments. As a result, they could not write on the subject. Consequently, the author intends to describe these items as follows:

Experimental plots were set in November 1989, and surveyed in November 1990 and October 1991. These plots were very small, 0.01 ha. for grass-mulching. The results obtained from the survey for both years are as shown in tables 7 and 8.

The effect of mulching on survival rates are clear in Prosopis juliflora and Tamarindus indica. The effect on height of trees indicates some

Table 7: Effects of mulching on survival rates (Unit: %)

Species	November 1990			October 1991		
	45x45	Stone	Grass	45x45	Stone	Grass
Acacia polyacantha	95.5	94.9	100.0	80.5	74.4	100.0
Cassia spectabilis	94.2	97.4	70.0	91.0	94.9	70.0
Croton megalocarpus	98.0	98.6	100.0	86.5	91.7	90.0
Prosopis juliflora	39.0	80.0	70.0	8.0	52.5	70.0
Tamarindus indica	69.0	79.4	90.0	27.0	69.9	90.0

Note 1 45x45 : Planted trees in hole size of 45 x 45cm
2 Stone : Stone mulching
3 Grass : Grass mulching

differences between the two methods. Thus height of the trees were very good in grass mulching method using Cynodon nlemfuensis. However, the author is sceptical that the prevailing soil conditions might have influenced these trees. The difference between grass mulching and the other methods is significant. Some precautions should be taken when using grass mulching method due to termite damages, however, there were less damages.

Table 8: Effects of mulching on height of trees (Units: cm)

Species	November 1990			October 1991		
	45x45	Stone	Grass	45x45	Stone	Grass
Acacia polyacantha	38	36	151	39.8	49.6	260.5
Cassia spectabilis	64	48	66	66.3	68.7	98.6
Croton megalocarpus	42	36	51	62.4	54.0	92.2
Prosopis juliflora	8	21	50	25.5	24.2	161.4
Tamarindus indica	12	19	37	12.7	20.9	46.0

Note 1 45x45 : Planted trees in hole size of 45 x 45 cm
2 Stone : Stone mulching
3 Grass : Grass mulching

3.2.2 Weeding

The purposes of weeding are to direct more sunshine to the planted seedlings and ease competition for water absorption in the soil between seedlings and bushes or weeds by slashing them. The effect of weeding which was done several times per year in experimental plots in the Pilot Forest was noted in the original report. Furthermore, Hori's comment insisted that weeding should be done completely. During the first Phase of Social Forestry Training Project, a well designed experiment of weeding could not be carried out in the Pilot Forest, however, of 119 ha, planted in 1988, weeding was carried out on only about half of the area. It seems useful to know effect of weeding by comparing areas which were weeded and those that were not weeded.

Weeding of compartments planted in 1988 was done from December 1988 to January 1989 by strip slashing method. However, because of shortage of labour about half of the compartments could not be weeded as mentioned. In the 1989 fiscal year, weeding was done in all areas. In addition the 1990, compartments with more than 30 % survival were weeded.

There were 8 species in some compartments which had weeding done while others were not done. The following are the results of the analysis of weeding of the 8 species.

It is first of all important to note that this analysis was not designed using an experimental design. Although there are some errors in the results, but still there are some lessons to be learnt, from it as a field experiment.

Table 9 shows the survival rate in some compartments planted in November 1988 and surveyed in July 1989, November 1989 and October 1990 respectively. The results of the November 1989 and October 1990 surveys shows that weeding enhanced survival rates.

In order to make clear the impact of weeding effect on shade tolerant species, 4 species of Mimosaceae family were picked up from Table 9 and listed in Table 10. The same was done in Table 11 for 3 species of Caesalpinaceae family. These two tables show that there is no significant difference between the weeded and unweeded compartments of both groups in survival rates in February 1989 just after the first weeding. However, according to the survival survey in July 1989, the difference in survival rate occurred between weeded and unweeded compartments in species of Mimosaceae family with minor difference in species of Caesalpinaceae family. The results of survival survey of November 1989 shows the difference becoming bigger between average survival rate of weeded compartments and unweeded ones. After 1989 plantation was finished, these compartments were weeded using the usual method, strip slash. The performances from the survival survey in October 1990 shows the differences in average survival rates were 12.3 % in Mimosaceae species and 14.4 % in Caesalpinaceae species.

It seems that weeding effect will diminish after one rainy season that will come after weeding in Mimosaceae species, and be continued for nearly 10 months including one rainy season in Caesalpinaceae. Estimating the necessary weeding times per year, Mimosaceae species will be 3 times and Caesalpinaceae species 2 times. However, the result comes from a few species and very short terms, so the author hopes that these observations will be continued.

Table 9: Survival rate (Unit: %)

Species	Weeding done					Weeding not done				
	Comp.	Area	Survival rate			Comp.	Area	Survival rate		
			J/89	N/89	O/90			J/89	N/89	O/90
A.g	I-F	1.42	85.0	77.0	43.5	I-J-3	2.60	87.0	-	47.5
	I-H	2.42	87.0	79.5	71.5	II-J-2	1.01	83.5	47.5	62.0
	I-P-3	0.40	85.0	-	43.8					
A.p	II-F-3	2.75	73.0	54.0	12.0	I-J-1	3.57	17.5	3.0	-
						II-C	3.50	79.0	45.0	51.0
						II-J-4	4.78	60.0	66.0	17.0
A.s	I-F	0.65	90.5	67.0	51.5	II-J-3	1.00	78.5	78.0	47.0
C.si	II-H-5	2.49	82.5	77.0	76.0	I-E-3	1.94	67.0	20.0	14.0
C.se	I-N	3.20	86.0	68.0	69.5	II-E-1	1.75	40.5	41.5	48.0
						II-G-1	4.94	93.5	71.0	59.0
C.m	I-J-2	2.81	90.5	93.0	91.5	I-E-1	3.38	89.0	89.5	85.5
	II-B	3.79	92.0	87.5	91.0	II-G-2	4.03	90.0	71.0	71.5
P.j	I-M	3.27	86.0	63.0	50.0	I-J-3	1.42	74.0	31.0	16.5
	II-E-2	3.76	89.5	71.0	67.5	II-H-1	3.85	82.5	65.5	44.5
T.i	I-H	2.05	80.0	52.0	36.5	I-E-2	3.92	84.5	68.0	48.5
	I-K	0.92	89.5	73.0	50.5	II-A	4.99	82.5	55.5	61.5
	II-H-4	2.76	94.5	79.5	83.5	II-H-3	1.02	88.5	64.5	69.5

Note 1 Comp: Compartment
2 J/89: July 1989, N/89: November 1989, O/90: October 1990
3 Species
A.g: Acacia gerrardii
A.p:Acacia polyacantha
A.s: Acacia senegal
C.si: Cassia siamea
C.se: Cassia spectabilis
C.m:Croton megalocarpus
P.j: Prosopis juliflora
T.i:Tamarindus indica
4 -:No data

Table 10: Survival rate of Mimosaceae (Unit: %)

Species	Comp.	Feb. 1989		Jul. 1989		Nov. 1989		Oct. 1990	
		D	N	D	N	D	N	D	N
Acacia gerrardii	I-F-1	97.5		85.0		77.0		43.5	
	I-H	98.5		87.0		79.5		71.5	
	I-P-2	96.7		85.0		-		43.8	
	I-J-3		98.0		87.0		-		47.5
	II-J-2		90.5		93.5		47.5		62.0
Acacia polyacantha	I-J-1		94.0		17.5		3.0		-
	II-C		98.0		79.0		54.0		51.0
	II-F-3	94.0		73.0		54.0		12.0	
	II-J-4		95.5		60.0		66.0		17.0
Acacia senegal	I-F	98.5		90.5		67.0		51.5	
	II-J-3		94.5		78.5		78.0		47.0
Prosopis juliflora	I-M	93.5		86.0		63.0		50.0	
	I-J-3		98.5		74.0		31.0		16.5
	II-E-2	94.5		89.5		71.0		67.5	
	II-H-1		96.5		82.5		65.5		44.5
Average		95.4	96.1	84.7	66.2	67.7	49.0	50.2	37.9
Balance		- 0.7		18.5		18.7		12.3	

Note 1. D: Weeding was done.
2. N: Weeding was not done.
3. Calculating in the average and balance.
Acacia polyacantha I-J-1 is omitted because of abnormality.
4. -: No data.

Table 11: Survival rate of Caesalpinaceae (Unit: %)

Species	Comp.	Feb. 1989		Jul 1989		Nov. 1989		Oct. 1990	
		D	N	D	N	D	N	D	N
Cassia siamea	I-E-3		95.0		67.0		22.0		14.0
	II-H-5	97.0		82.5		77.0		76.0	
Cassia spectabilis	I-N	98.0		86.0		68.0		69.5	
	II-E-1		48.0		40.5		41.5		48.0
	II-G-1		90.5		93.5		71.0		59.5
Tamarindus indica	I-E-2		94.0		84.5		68.0		48.5
	I-H	93.0		80.0		52.0		36.5	
	I-K	97.0		89.5		73.0		50.0	
	II-A		94.5		82.5		55.5		61.5
	II-H-3		96.5		88.5		64.5		69.5
	II-H-4	98.0		94.5		79.5		83.5	
Average		96.8	89.1	86.5	80.6	70.3	57.9	66.8	52.4
Balance		7.7		5.9		12.4		14.4	

Note 1. D: Weeding was done.
2. N: Weeding was not done.
3. -: No data.

3.3 Performance of planted species

3.3.1 General

Determination of which species available in Kwa-vonza Location belonging to semi-arid area is one of the most important objectives. So far the project has had enough data to determine what species are good for the location to plant. The author recommends that the following 8 species planted in 1988, would be available to be introduced in Kwa-vonza Location under the criteria that more than 60% in survival rate and more than 50 cm in average tree height at survey of October 1990.

Acacia nilotica
C. spectabilis
Dalbergia melanoxylon
Grevillea robusta
Cassia siamea
Croton megalocarpus
Gmelia arborea
Prosopis juliflora

NB: Acacia polyacantha and Tamarindus indica are not included above because A. polyacantha could not meet the set criteria, and T. indica could not attain the expected average tree height. However, A. polyacantha may not be given up due to its first growth rate, and T. indica may not be given up due to its good survival.

Candidates species would be chosen from those species planted in 1989 following the same criteria mentioned above after about two years from establishment period. The species listed below could be chosen. However, take note that hole sizes of plantation established in 1989 was mostly 65 x 65 cm in diameter and depth.

Acacia gerrardii
A. polyacantha
C. spectabilis
Eucalyptus camaldulensis
A. nilotica
Cassia siamea
Croton megalocarpus

The reasons for not listing some species which were included in 1988 plantation but not in 1989 are as follows:
Dalbergia melanoxylon did not excel in average tree height.
Gmelia arborea was not planted in 1989.
Grevillea robusta had a survival rate of 52.5% and 107.3cm in average tree height.
Compartments of Prosopis juliflora plantations had significant variations in survival rates and average tree height. Some compartments conformed to the criteria while others did not.

It is apparent that following 12 species would be chosen as appropriate species to be planted in the Pilot Forest in terms of performance by the end of 1991. There might be some other prospective species, if seen provenance, soil condition, climatic condition, seedling production techniques etc would be favourable. There may also be some species which have yet to be introduced.

Acacia gerrardii
A. polyacantha
C. spectabilis
Eucalyptus camaldulensis
Gmelia arborea
Prosopis juliflora
A. nilotica
Cassia siamea
Croton megalocarpus
Dalbergia melanoxylon
Grevillea robusta
Tamarindus indica

The above listed species are chosen from the results of plantation establishment from 1988 to 1991. The annual precipitation in semi-arid area is characteristically very erratic. For example, the total precipitation in 1990 in Tiva Nursery was 1120.5mm, and that of 1991 was 724.8mm. However, the total precipitation from 1 January 1992 to 30 September 1992 was only about 80mm. Under this severe condition, Cassia spectabilis, Eucalyptus camaldulensis and Grevillea robusta should be re-examined about tolerance of drought. It is the author's contention that the above mentioned species should be omitted from 12 appropriate species because of intolerance to drought. Dalbergia melanoxylon should be re-observed on damage by dik-diks. Likewise Eucalyptus camaldulensis and Grevillea robusta for damage by termites.

3.3.2 A Comment on the Performance of Acacia polyacantha

According to the original report, considerable differences in the results of the trial plantation depended mostly on the potentialities the outplanted seedings had, rather than conditions of the area such as soil condition, climatic conditions, luxuriant weed growth and bushes,

management methods etc. Prof. Asakawa pointed out that prevailing conditions in the areas planted affected the survival more strongly in the earlier period of establishment. However, Watanabe's comment contended that while the possibility of the above mentioned difference would largely depend on potentiality of this seedling, the idea was still at the hypothesis stage.

Therefore, Mr. K. Watanabe emphasised the need to be careful about the provenances and further pointed out the need to raise healthy and vigorous seedlings for outplanting. Hori's comment, reflected on activities of seed collection in earlier stage of the Pilot Forest activities. The good seedling performance during early stages of establishment is determined by the potentiality of seedlings and, therefore, good seedling production is a factor that cannot be ignored.

There is a case in Acacia polyacantha in which significant difference in performance occurred in the same species. There are 3 compartments in which A.polyacantha was planted in 1987. The performance of these 3 compartments are shown in table 12. However, not all of these compartments were planted. Furthermore, since the survival survey was not done in all trees, there might be some errors.

Table 12 Survival Rates and Heights of Acacia polyacantha

Comp	Survival Rate						Height cm	
	Jan/88	My/88	Feb/89	Jul/89	O/90	O/91	O/90	O/91
1	99.0	79.0	79.5	77.0	59.0	63.0	267	369
2	99.0	51.0	51.5	44.5	34.0	32.0	134	191
3	98.5	74.0	57.0	55.0	23.5	24.0	115	164

Note:

Jan/88 : January 1988,
My/88 : May 1988,
Feb/89 : February 1989
Jul/89 : July 1989,
O/90 : October 1990,
O/91 : October 1991

There is very large difference between compartment No.1 and No.3, as shown in table 12. If the site conditions, such as soil condition, luxuriant growth of weeds and bushes, density of remaining trees, etc, would be the same and mother trees from which seeds were obtained are different from each other compartments, the argument in the original report would be correct. However, there are some differences between two compartments in site condition especially in soil condition. In compartment No.1, the soil is deep and abound in organic matter compared with compartment No.3, also less errored and less remnant taller trees than compartment No.3.

The average tree height both compartments in October 1991, that is 4 years after planting, were 369 cm and 164 cm respectively. The result of this difference might depend mostly on site condition, though the vigour which the outplanted seedlings had is an undeniable factor.

3.3.3 Details of some planted species

51 species have been planted in the Pilot Forest from 1986 to 1991. The following are short comments on almost all the species planted in the area by 1989.

In the following there are surveys conducted several times for survival rates and average tree heights. The author wishes to draw some attention to these timings since some intervals are a matter of months.

Acacia spp.

The genus Acacia is very large, and Kenya has over 60 indigenous Acacia species, Noad et. al, (1989). There are many species which produce good timber and are very tolerant to drought, as observed in Asakawa's comment. It further observes that Acacia spp. have been used over many years, and there is a small possibility that several trees have good genetic qualities. Therefore, seeds of Acacia spp. should be collected from good quality seed trees.

Naturally regenerated Acacia spp. in the area between Tiva Nursery and Tiva River will continue to be tended. However, more consideration will continue to be given to only good trees that will remain for seed collection in the future. Indeed, seed of Acacia gerrardii is collected from some trees in the area to raise up seedlings in Tiva Nursery for planting in the Pilot Forest.

Acacia spp. originating from Australia should also be examined so as to be able to choose or select some appropriate species for the Pilot Forest, however, none of these exotic Acacias have shown good performance in the Pilot Forest so far.

It is necessary to examine more Acacia species both of indigenous and Australian. At the time of examining some of these species, it is very important to note their provenance because any wrong decision taken will not only affect seedling growth at nursery stage but also has a long term effect on the plantation area.

Acacia abyssinica
This species occurs at the edges of highland forest down to Limuru and Muguga and in wooded grassland from 1,800 to 2,400 m, Noad et. al, (1989). Mr.Y. Watanabe in the original report considered this species as unsuitable for planting in the Pilot Forest because of the severity of drought in this area. Asakawa et. al (1990) observed some experiment that the development of this species' root system was not rapid. Therefore, this might be one of the reasons why this species cannot perform well in the Pilot Forest.

Acacia albida
This species is widely distributed from 550 to 1,800 m, often riverine in dry areas or where the water table is near the surface, Noad et. al, (1989). The species can also grow up in some areas which get from 300 to 1,800 mm precipitation and is tolerant to drought, Von Maydel, (1986). The root system of the species extends deep into the soil, and does not compete with agricultural crops. Therefore, the species can be used for agroforestry purpose.

Almost all of the seedlings of this species planted in 1987 and 1988 died. As a result, Mr. Y. Watanabe observed in the original report that this species could not be grown in the Pilot Forest. However, there might be some other reasons for the poor performance, because the species is very tolerant to drought.

Acacia auriculiformis

This species comes from Queensland, Australia. Seedlings of the species were planted in a compartment in 1988. The performance of this compartment was very poor. The survival rate was 20% and average tree height was 75 cm in October 1990 and 14% and 245.5 cm respectively in October 1991. The species can grow in some areas with more than 600 mm of precipitation, Carlowitz, (1986). However it is suitable as a forest plantation crop at altitudes up to about 600 m, Von Maydel, (1986). It seems that the species will show better performance in higher precipitation area. The species has been severely damaged by drought this year (1992). It is necessary to consider to seek more drought tolerant seed from some related provenance.

Acacia gerrardii

This species is naturally distributed around Tiva Nursery, and is familiar with farmers as fuelwood and charcoal wood. Growth rate is rather slow, but many farmers plant it. The species should be one of the important planting species in Kwa-vonza Location. The performance of the species is good in some compartments.

Acacia holosericea

This species comes from Australia. It takes a long time to grow in the nursery, and it seems its growth rate is also rather slow in the field. It is susceptible to be damaged by dik-diks soon after planting. The species seems inappropriate for planting in the Pilot Forest.

Acacia nilotica

This species is widely distributed in Kenya, and grows with annual precipitation between 250 and 1,000 mm and tolerates high temperature, Von Maydel, (1986). There are many subspecies and varieties, which might have different characteristics. According to a survey done in November 1990, seedlings of the species planted in 1989 were 96% in survival rate and 50 cm in average tree height, and 91.9% and 56 cm respectively, from the result of survey done in October 1991. Although the species prefers neutral or alkaline soil, Carlowitz (1986), the species should be one of the potential species worth monitoring in growth.

Acacia pendula

This species comes from Australia. The species seems to be able to grow in semi-arid area which has more than 250 mm precipitation, Carlowitz, (1986). The species was planted in 3 compartments in 1989. According to survey done in October 1991, the best compartment had 31% survival rate and 19.1 cm in average tree height, and almost all trees died in the worst compartment. As the species prefers alkaline soils, Carlowitz, (1986), there is some anxiety to plant the species in the Pilot Forest because of the soil condition of the site.

Acacia polyacantha
This species is widely distributed in Kenya from 200 to 1,800 m, Noad et. al, (1989). The surviving trees of this species planted in 1987 have grown very well. However, some trees which were planted under the dense canopy of existing trees indicated low survival rate and not as good growth as reported in the original report. Some compartments planted with the species in 1988 had poor survival rate compared with those planted in the 1987 compartments. According to the original report, the reason why this was not so good in performance was insufficient weeding in the 1988 compartments. This species is highly shade intolerant hence its poor performance. 6 compartments planted with the species in 1989 show variable survival rates from 17% to 94% and in tree average height from 19 cm to 101 cm in October 1991.
The species shows good growth in full sunshine and is affected by soil condition. The species is fast growing, grows to big tree, tolerant to termite, has various use and is a potential species for fuelwood in Kitui area. Many farmers plant it as fuelwood in Kwa-vonza Location.

Acacia salicina
This species comes from Australia. The species seems to be able to grow in semi-arid area with more than 250 mm precipitation, Carlowitz, (1986). Two compartments of the species planted in 1989 showed poor performance, 22% and 17% in survival rates, and 14.5 cm and 17 cm in average tree height in October 1991.

Acacia senegal
This species is widely distributed in dry grassland of Kenya, Noad et. al, (1989). The species is very drought tolerant, prefers sandy to sandy-clay soil. There are many of these trees around the Pilot Forest. The performance of two compartments of the species planted in 1988 were 46% and 36% in survival rates, 19.6 cm and 15.7 cm in average tree height in October 1991. Although growth rate of the species is slow, the species should be noted and its growth rate monitored.

Acacia tortilis
This species is widely distributed up to 1,800 m in woodland, grassland and semi-desert areas, Noad et. al, (1989). The species can be divided into some sub-species and varieties. Although growth of the species is rather slow, it grows relatively fast on dry sandy soil if well managed, Teel, (1988). Performances of the species planted in 1988 and 1989 were not good, the performance of the area planted in 1988 was 37.4% in survival rate and 22 cm in average tree height, and in 1989 area planted was 49.0% and 23.4 cm respectively in October 1991. The species prefers neutral and alkaline soil, Carlowitz, (1986), therefore, there is some anxiety to plant the species into the Pilot Forest because of soil condition.

Acacia xanthophloea
This species is gregarious in high ground water area beside lakes or river from 600 to 2,00 m, often in black cotton soil, Noad et. al, (1989).

There are some trees around black cotton soil area in the Pilot Forest, as indicated in the original report. All the seedlings of the species planted in 1987 died. The performance of the species in a compartment planted in 1988 was 36.0% in survival rate and 96.9 cm in average tree height, and in 1989 area planted was 43.8% and 66.8 cm respectively in

October 1991. This performance means the species is capable of growing even in the Pilot Forest if ground water level would be high. The species grows fast and big, has various uses and should be noted and its growth monitored.

Acrocarpus fraxinifolius
This species is native to India and South East Asia, and introduced in coffee and tea plantations as shade tree, Noad et. al, (1989). The species grows very well in high precipitation areas, however there are some difficulties in planting in the Pilot Forest because of insufficient precipitation. As there are some big trees of the species in Kitui Town, the species seems to grow in some areas of the District which receive more precipitation than that of the Pilot Forest.

Albizia amara
This species is distributed in woodland at lower to medium altitudes of Kenya, Noad et. al, (1989). Performance of a compartment planted with the species in 1989 was 94% in survival rate and 23 cm in average tree height in November 1990, and 75% and 27 cm respectively in October 1991. Growth rate of the species is slow in the nursery and seems to be slow in field.

Albizia anthelmintica
This species is a common shrub of the dry bushland in Kenya, Gathathi, (1989). Performance of a compartment planted with the species in 1989 was 80% in survival rate and 15 cm in average tree height in November 1990, and 66.5% and 18.8 cm respectively in October 1991. The growth rate of the species is very slow both in the nursery and field.

Azadirachta indica
This species is native to India and Sri Lanka, a valuable species with multiple uses, planted widely at the coast area for fuel, timber and shade, and increasingly used in agroforestry in exhausted soil, Noad et. al, (1989). The species grows fast, its leaves are used as medicine and is familiar with farmers. The species was planted in 1986, 1987 and 1988, all compartments were poor in performances.

The species prefers sandy and alkaline soil, and is shade intolerant. Therefore, there are some negative factors in the Pilot Forest such as remnant standing trees and soil condition which combine to cause poor performance. It seems examination of provenance, strain and soil condition will be necessary, as in Asakawa's comment. Mr.K.Watanabe observed that the species is preferred by farmers in Africa.

Balanites aegyptiaca
This species is distributed in savannah grassland from sea-level to 2,000m, often in sandy or black cotton soils, Gathathi, (1989). The species has multiple uses. There are some trees in the Pilot Forest. The species seems to be drought tolerant, however, performance of the species was not good. The reason why it was not good is unclear. However, according to original report, it seems seedlings of the species were killed by shading effect, because of having many standing remnant trees, insufficient weeding, luxuriant growth of weeds and bushes.

Cassia siamea
This species is native to India and South East Asia, and has been widely planted in lowland of East Africa, Noad et. al, (1989). The species has shown good performance in the Pilot Forest in the 1988 plantation. From the encouraging results in the demonstration area by the Tiva Nursery and field the species deserves to be considered one of the adequate tree species for planting in the Pilot Forest. As in the original report, there are a few cases of die-back. In addition, some diseases of the leaves (may be powdery mildew) occur very often.

The result of performance in the plantation established by stump seedling shows that it is possible to carry out the practice using this method. This was done in 1991. The severe drought in 1992 made almost all stump seedlings to die. The trial should be done again. Usually seedlings which are one year old after planting are usually tolerant to dryness in sufficient sunlight condition. However, because of severe drought this year (1992) and soil condition, some trees of the species planted in 1990 died.

Cassia spectabilis
This species is native to tropical America, and is widely planted upto 2,000 m in Kenya. In Nairobi, the species is planted as an ornamental tree. The species grows well in suitable moist and fertile soils.

As land preparation of compartments of the species planted in 1988, were carried out in strip clearing with 1m width, seedlings were easily covered with weeds and bushes. The result of this was death of seedlings. Performances in the experiment area with the Turkana method and planting hole size with the species were very good. As the experiment areas were weeded many times, this might have attributed partly to the observed performance. Considering these facts in weeding, it is reasonable to acknowledge why the original report emphasized the necessity of weeding.

Die-back of the species was remarkable, take for instance compartment II-E-1 planted in 1988, the results of survey in October 1990 revealed 48% in survival rate and 66 cm in average tree height, while in October 1991, 44% and 66.3 cm respectively. These trees grew very fast. This year's drought resulted into very severe damage on the plantation of this species. For instance, in the above mentioned planting hole size experimental plot, many of the trees died.

The species has the same establishment potential as C. siamea in stump seedling plantation, although deaths do result from drought.

Casuarina equisetifolia
This species is planted in coastal areas and has done surprisingly well in higher elevations including Nairobi, Teel, (1988). Performance of the species in the Pilot Forest has not been good. This might be attributed to the species preference to sandy soils, and necessity of Frankia inoculation in a new plantation site.

Croton megalocarpus
The species is common around Nairobi and in dry upland forest often planted in the countryside as a boundary marker, Noad et. al, (1989). The fact that this species was mentioned in detail in the original report, was a matter of concern in the Asakawa's comment.

Prof. Asakawa emphasized the necessity of recording, while Mr. Hori maintained the necessity of analysis of the performance of 1988 plantation compartments.

A survey comparing the relationship between tree height and relative light illuminance was done in some compartments in the Pilot Forest. The result revealed a negative correlation between both factors. This means the species has some shade tolerance.

The performance of the species in the Pilot Forest was very good except in some compartments planted in 1987. However, there are some differences in height between compartments planted in the same year, and there is need to examine the reason for this difference.

The species was evaluated where the establishment was done using stump seedlings in 1991, however, the performance was the same as C. siamea.

Darlbergia melanoxylon
This species is scattered in low altitude savannah and woodland below 1,300 m in Kibwezi and Kitui areas, Noad et. al, (1989). Although big or medium sized trees are not seen in the Pilot Forest, the original report mentioned that there were many small trees of the species. This means that the species may be adopted for planting in the Pilot Forest.

Although growth rate was slow, the performance of the species had been very good in a compartment planted in 1988. The performance was 97.5% in survival rate and 57 cm in average tree height in October 1990, and 98.0% and 33.1 cm respectively in October 1991, because of damage by dik-diks. There are some of the young naturally growing trees which are also damaged by dik-diks.

Delonix regia
This species is native to Madagascar, common at the coast, Noad et.al (1989). There are some of these trees in Kitui Town. The growth rate of the species is generally better in the high humid areas such as Kisumu. Planting the species in the Pilot Forest seems to be inappropriate. All the seedlings planted in 1988 died.

Eucalyptus spp.
There were some opinions expressed about this genus in not only the original report but also in the other three comments. According to the original report, although seedlings of Eucalyptus spp. grow very fast, they are attacked by termites and browsed by dik-diks very severely. Therefore, some species of this genus seems not to be suitable to establish in an area larger than some pre-determined sizes in dry areas like Kitui. The comments to this opinion were that plantation trials of some Eucalyptus species, without an idea of provenance, was observed as inappropriate in Asakawa's comment, and even though it would not be easy to establish forest of some size, trial plantation of Eucalyptus spp. should be continued for farmers as indicated in Watanabe's and Hori's comments.

Eucalyptus camaldulensis
This species is native to Eastern Australia, Noad et. al, (1989). The species grows very fast, it reaches 3 m in height for two years if the

prevailing condition of planted area is good. A compartment of the species planted in 1989, was 82.5% in survival rate and 174 cm in average tree height in October 1990, and 76% and 227 cm respectively in October 1991. The performance seemed to show some prospects that the species would be planted in the Pilot Forest, if there was no damage by termites. However, the species was severely damaged by this year's drought, and some trees in Tiva Nursery which were already 10 cm in diameter died from termite attack.

Eucalyptus citriodora
This species is native to Australia. The species was tried only in 1987, but did not give good performance. However, take note that almost all trial plantation planted in 1987 did not perform well.

Eucalyptus paniculata
This species is native to coastal Queensland, New South Wales, Australia, Noad et. al, (1989). The performance of trial plantation in 1987 was the same as E. citriodora. Performance of trial plantation planted in 1989 was 15.9% in survival rate and 82.1 cm in average tree height according to a survey done in October 1991.

Eucalyptus tereticornis
This species is native to Australia. The performance of trial plantation in 1987 was the same as E. citriodora. Performance of trial plantation planted in 1989 was 69% in survival rate and 117 cm in average tree height according to a survey done in November 1990, and 46.5% and 166.2 cm respectively in October 1991. The species is prospective in Pilot Forest, however, just as it is with E. camaldulensis, the species is susceptible to termite attacks.

Gmelina arborea
This species is native to the moist forest of South Asia, from India through Southern China, Teel, (1988). According to the original report and as mentioned above, it is very difficult to grow the species in Kitui area, because of less precipitation than its area of origin. Mr.Y.Watanabe noted in the original report that the species planted in 1988 was growing very well, and it was necessary to observe how it is performing. Although the planted area in 1988 is only 0.12 ha, the performance of the compartment was 87.7% in survival rate and 160.8 cm in average tree height in October 1991. The species seemed to be successful in the Pilot Forest. However, the species was severely damaged by this year's (1992) drought, leading to a die-back situation. Therefore, it is very important to observe its recovery process. The author is optimistic that the damaged trees will have recovered by the next rainy season. There are some trees growing very well in the coastal area of Kenya.

Grevillea robusta
This species is native to Eastern Australia and is very widely planted from 1,200 m in Kenya. This species has been planted in enormous numbers worldwide. In Kenya it was originally introduced as a coffee shade tree, but is now largely grown for fuel, timber and as a windbreak, Noad et.al, (1989).
According to the original report, the species' tolerance to drought is rather weak. However, according to Asakawa's comment, the species will be introduced in some areas with more than 600 mm of annual

precipitation. And both the report and comment have strongly cautioned the need for careful choice of appropriate provenances.

The performance of the trial plantations of 1986 and 1987 were not good. According to the original report, all of the seedlings planted in 1986 died and in the case of those planted in 1987, the seedlings were considered to have died because of suppression resulting from competition by shrubs and weeds, even though the soil condition was good.

The performance of trial plantation in 1988 was good by 1991, however, site condition was the same as that of 1986 and 1987. Therefore, Mr.Y.Watanabe concluded in his original report that the reason why they were so different was due to provenance differences. In comparison with the above mentioned conclusion, Watanabe's and Hori's comments considered the difference to be due to differences in precipitation. The performance of trial plantation planted in 1988 was also very good, as there was difference in precipitation between 1988 and 1989, so it is more understandable than provenance differences. Hence the explanation for differences in performance depended mainly on difference in precipitation. Of course, it is also undeniable that some effects of provenance and planting techniques played an important role.

Performance of trial plantation in 1988 and 1989 were 59.5% and 52.5% in survival rates, and 94.6 cm and 107.3 cm in average tree height respectively in October 1991. The species is very susceptible to termites. Some trees which had grown more than 2 m in height, died due to this year's (1992) severe drought.

Leucaena leucocephala

This species is native to Central America. The species has an unreserved reputation for drought tolerance, and it does best near the coast and in the places like Kitui, Kisumu/Murang'a climate types, Teel,(1988). The original report indicates that the species is very palatable to dik-diks, therefore the repeated effects of browsing inhibits tree growth and therefore the trees damaged by drought die easily. Although the species had been planted every year from 1987 to 1989, the performances have not been good. Only a few of the trees planted in 1987 are remaining and are more than 3 m in height. This means that it would be prospective to grow the species if there would be no damage by dick-diks.

As the species is shade intolerant and its taproot system grows deep into the soil, the species is a recommendable agroforestry tree. The species grows well in soil condition of neutral or alkaline, and does not grow well in high altitude areas with some provenances, Carlowitz, (1986), National Academy of Science, (1990). Therefore, the performance of the species might depend on soil reaction, sunshine condition and provenance of planted trees.

Melia azedarach

According to Asakawa's comment, this species is distributed from Southern Japan to South Asia, and there is a theory that it originated at the foot of Himalayas. It is also said that the species is native to Western Asia and Himalayas and is fairly widely planted in Kenya up to 2,000 m, Noad et.al,(1989).

The species can grow in dry areas. The species was planted in 1987 and 1988. Although the performance was not good as indicated in the original report, Mr.Y.Watanabe was optimistic over the possibility of successfully establishing this species in the Pilot Forest. If not, then it seems the reason would be more of soil condition than precipitation.

Melia volkensii
This species is widely distributed from sea-level to 1,200 m in lower semi-arid savannah districts such as Kitui, Machakos, Samburu, Taita and Voi. The species is also planted for agroforestry, as the fallen leaves provide a good mulch and the flowers encourage bees, Noad et. al, (1989).

The original report indicates that there are some small trees of this species around and in the Pilot Forest. This is a clear manifestation that the species is preferred by farmers. The species and Terminalia brownii have seed germination problems, so it is often very difficult to get good germination rates. The project is hopeful to come up with some appropriate techniques to alleviate this problem. According to Asakawa's comment, root sucker method is a possible technique.

The performance of the species planted in 1987 was not good, the original report could not make clear reason why it was so, that is, whether it is because of soil condition, drought intolerance or inadequate precipitation this year (1992). The performance of a compartment planted with the species in 1989 was 30.5% in survival rate and 30 cm in average tree height in November 1990. The species grows very fast, especially in regeneration by sprouting.

Moringa stenopetala
This species is common near Isiolo and on the islands of Lake Baringo, Noad et. al, (1989). The species seems to be drought tolerant in its distribution. The performance of a compartment of the species planted in 1988 was not good.

Parkinsonia aculeata
This species is native to tropical America, and is widely planted in poor or sandy soils at lower altitudes for fuel and fodder in Kenya, Noad et. al, (1989). The species grows well where annual precipitation is as high as 1,000 mm, but its greatest potential is in dry area receiving as little as 200 mm annually and having dry season as long as 9 months, National Academy of Science, (1980).

Though the species was planted in 1987 and 1988, the performances were not good, as indicated by the original report. The report, further indicated that the fact that the species was preferred by farmers near the Tiva Nursery, had growth rate and that the trees planted in the nursery grew well. However, the species needs enough sunshine to enhance fast growth. The species is shade intolerant and in shaded sites its growth is retarded, National Academy of Science (1980). The species grows well in alkaline soils, Carlowitz, (1986), and soil condition of the Pilot Forest might be one of the reasons why the performance of the species was not good.

Prosopis juliflora
This species is native to South-western U.S. and Mexico. The species is widely planted from the coast to Turkana district, Teel, (1988). The species has been planted every year from 1986. However, the performances have been very different. It established well in some compartments but not in others. As the species is shade intolerant, tree growth is retarded where there are some remnant standing trees. The original report indicated that the species required good soil and that growth was not good in poor soil. The species prefers sandy soils, for instance, growth in trial plantation near Lake Baringo is very good. The reason why performance of the species is not good might partly be on soil condition, indeed the species prefers alkaline soils, Carlowitz, (1986).

According to original report, tree form of the species will become bushy, so there will be some problems related to use as timber. The species is also very easily susceptible to dik-diks. It is against this opinion relating to tree form, that Mr.K.Watanabe commented that tree form should be considered from the stand points of the farmers. To the farmers, if a tree gives good fuelwood, it is considered to be a good tree, no matter whether it would be in bush form or bent.

As Hori commented, the species is very complicated compared with other species. Taxonomy of the genus Prosopis is a bit confusing. The specific name juliflora has been used in the past to describe species native to Texas and nearby States. These are now known as P. glandulase and P. velutina. Plants that were distributed around the world under the name P. juliflora are probably mislabelled, National Academy of Science, (1980).

Schinus molle
This species is native to Peru and Andes and is commonly planted in dry, warm climates in many parts of the world as well as most districts of Kenya. The species is very tolerant to most soils, including both black cotton and dry sandy soils, Noad et. al, (1989). The performance of this species planted in 1988 was not good.

Sesbania sesbans
This species is widely distributed from 1,300 to 2,000 m, often along rivers or swampy ground, particularly in Nyanza, Noad et. al, (1989). The species grows fast and is used as agroforestry tree. According to Hori's comment, the Pilot Forest is more marginal to establish the species, however, there might be some other reasons for the poor performance. According to the original report, the species is very palatable to dik-diks, and as a result of repeated browsing, the trees remain stunted. The trees so damaged eventually die easily due to drought. The performance of this species planted in 1987 was not good.

Tamarindus indica
This species is widely distributed in drier grassland from the coast to 1,500 m, and develops long, deep roots and is deciduous under very dry conditions, Noad et. al, (1989). The species is shade tolerant during the early stage of development as observed in the original report.

Trial plantation establishment of the species has been carried out every year since 1986. The survival rates of the trees were mostly good except in compartments planted in 1987. However, growth rate was very slow. A compartment planted in 1986, in which an area of 0.63 ha was beaten-up with 330 trees, had an average height of 103 cm by October 1990. According to Hori's comment, the area planted has very good soil condition and beating up, hence the results should be evaluated with reduction. However, there is no need to reduce so much, because of beating-up but with very few trees.

Original report mentioned the species as shade tolerant and it is against this opinion that Watanabe's comment pointed out the need for more systematic experiments. A survey of tree height and relative light illumination was done in some compartments with this species in the Pilot Forest. The results could not show any correlation between both factors.

As at establishment, the seedlings used for planting were big and therefore, there is need to determine the right planting size right from the nursery stage.

Terminalia brownii
This species is widely distributed in the drier wooded savanna from 700 to 2,000 m, often near rivers in very dry areas, Noad et. al, (1989). The performance of a compartment planted in 1989 was 95% in survival rate and 30 cm in average tree height as indicated by survey done in November 1990, and 90.5% and 37.7 cm respectively in October 1991.

Farmers in Kwa-vonza Location plant this species in their compound, and there are many of these trees in the Pilot Forest. The species has a seed germination problem, so it has been difficult to get good germination rate. However, the project is hopeful of coming up with appropriate techniques to enhance germination capacity of seeds of this species.

Terminalia catappa
This species is native to Andaman Island, India and Madagascar, and common in coastal areas throughout the tropics and widely planted at the coast, also in up-country districts such as Voi, Nairobi and Kisumu, Noad et. al, (1989). It is difficult to establish the species in the Pilot Forest due to the restrictive nature of the annual precipitation. All the trees of this species had died by October, 1991.

Terminalia prunoides
This species occurs in coastal forests and dry Acacia bushland in the Taita, Tana and Lamu Districts from 30 to 1,400 m, usually in drier areas than T. brownii, Noad et. al, (1989). The performance of a compartment of the species planted in 1988 was 79.5% in survival rate and 31 cm in average tree height in October 1990, and 76.0% and 38.1 cm respectively, in October 1991. Growth rate of the species is slow.

4.0 Acknowledgement

I wish to acknowledge the professional support provided to the project by Professor Sumihiko Asakawa of Tamagawa University, Japan, who visited the project on several occasions as a short-term silvicultural expert.

I wish to extend my sincere thanks and gratitude to all individuals who are the authors of the severally cited literatures. I have benefitted a lot from the two working papers (unpublished) which were written by the Japanese Experts and their counterparts in the Pilot Forest Scheme. I also wish to extend my sincere thanks and gratitude to all Japanese and Kenyan staff concerned with the implementation of the Project since the beginning of the Pilot Forest Scheme.

I have been in the Kenya Forestry Research Institute as a Japanese expert for more than three years carrying on with the implementation of the technical cooperation extended to Kenya by the Government of Japan. During those years, I have learnt many things especially in semi-arid area social forestry. This has not only been challenging, but also enjoyable. My heartfelt thanks are due to both Japanese and Kenyan Governments, and also JICA. Thanks to Dr. Odera's good and kind cooperation in the implementation of the Project activities, I have been able to work very comfortably, so I must appreciate his cooperation sincerely. I also wish to thank Mrs. Caroline Sikuku for typing this paper.

Finally, I hope that the Japan/Kenya Social Forestry Training Project, which will be continued for another 5 years from 26th November 1992 as phase II, will be most successful and that the Project will be serviceable to strengthen the tie of friendship between Japan and Kenya through technical cooperation in forestry.

5.0 REFERENCES

Asakawa S. 1991. A comment on "An Observation on the Pilot Forest Operation" (In Japanese, Unpublished).

Asakawa S. et. al: 1990, Root growth and Leaf Stomatal Density of Acacia Seedlings, Bulletin of the Faculty of Agriculture, Tamagawa University, No. 30, 1990 .

Carlowitz P.G.: 1990 Multipurpose Trees and Shrubs Seed Director, ICRAF, First Ed., May 1986.

Gachathi F. N.: 1989, Kikuyu Botanical Dictionary, First Published 1989.

Hori M., 1991; A Comment on "An Observation on the Pilot Forest Operation" (In Japanese, Unpublished).

Noad T.C. et. al,: 1989 Trees of Kenya, 1989.

NAS, 1990; Firewood Crops; National Academy of Science, Washington D.C.

Takahashi M. et al,: 1992 Working Paper of the Pilot Forest, (Unpublished).

Teel Wayne, 1988; A Pocket Directory of Trees and Seeds in Kenya, Kenya Energy Non-Governmental Organization.

Von Maydell Hans-J., 1986; Trees and Shrubs of the Sahel, GTZ.

Watanabe K. 1991; A Comment on "An Observation on the Pilot Forest Operation" (In Japanese, Unpublished).

Watanabe Y., 1990; Working Paper of the Pilot Forest, (Unpublished).

- 1991; An Observation on the Pilot Forest Operation. (In Japanese Unpublished).