Republic of Kenya

Kenya Forestry Research Institute

Republic of Kenya

Capacity Development Project for Sustainable Forest Management in the Republic of Kenya

(Tree Breeding Component)

Completion Report

November 2021

Japan International Cooperation Agency

(JICA)

Forestry and Products Research Institute

Forest Tree Breeding Center (FFPRI-FTBC)

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Contents

Chapter 1 Outline of the project 1
1. Background and objective of the project 1
1.1 Background 1
1.2 Objective of the project 2
(1) Overall Goal 2
(2) Project Purpose 2
(3) Outputs 2
1.3 Period of the project 2
1.4 Implementation agencies 2
2. Purpose of work 2
3. Target area of work 3
Chapter 2 Contents of activities 4
1. Basic Policy of activities 4
2. Implementation of activities 6
2.1 (Activity 4-1) Improve the quality of clonal seed orchard of Melia volkensii 6
2.2 (Activity 4-2) Study of artificial crossing towards second generation of Melia volkensii 11
2.3 (Activity 4-3) improve the seedling seed stand of Acacia tortilis 12
2.4 General work 14
Chapter 3 Challenge and Lessons learnt 17
1. Challenge and Lessons learnt on implementation 17
1.1 Method of implementation activities 17
1.2 Management Policy 18
2. Management of operation 20
3. Member of experts 21
Chapter 4 Achievement of work 22
1. Achievement of output 22
2. Situation of activities 22
Chaper5 Recommend for future 26

Appendix 27

Chapter 1 Outline of the project

1. Background and objective of the project

1.1 Background

In Kenya, the arid and semi-arid areas (ASALs) account for 80% of the land area, and the forest area occupies only 5.9%[1] in 2018. About 70% of energy source consumed in Kenya are accounted for by fuel wood and transferring the forest area to farm lands is proceeding. Conservation and reservation of the natural resources, therefore, is considered to be the important national issue in Kenya.

Furthermore, Kenya has been considered to be one of the most vulnerable country to climate change and frequent extreme climate events such as heavy drought or strong wind could be concerned. Promotion of REDD+ (Reducing emissions from deforestation and forest degradation) and capacity development for sustainable forest management are considered as the most important developing issues in terms of mitigation of climate change as well as expansion of forest areas.

The Kenya's national development program, Vision 2030, states that it aims to achieve a minimum 10% forest cover by 2030, which was 5.9% in 2018. In this situation, the government of Kenya has established National Forest Programme (NFP) 2016-2030 which aims at sustainably managed forests and allied natural resources for social economic growth and climate resilience and increases forest/tree cover to at least 10% on public, private, and community lands. And the government of Kenya has set the goal of increasing and maintaining the national tree cover to at least 10% by 2022.

Since establishment of Kenya Forest Research Institute (KEFRI) by Japanese grant aid, Japanese government has implemented technical cooperation with KEFRI and Kenya Forest Service (KFS) through promotion of social forestry in Kenya for more than 30 years. Recently "Project on development of drought tolerant trees for adaptation to climate change in drylands of Kenya (2012～2017)" had been implemented for enhancing research ability of KEFRI and extension system to promote planting indigenous trees in ASALs. All the while "The Forest Preservation Programme (2010-2013)" had been implemented as a grant aid environment program to support making land use map and so on for contribution to establishment of National Forest Monitoring System (NFMS) on REDD+. KEFRI, furthermore, has implemented "Social Forestry for adaptation to climate change (2014～2018)" as the 5th phase of a third country climate change action and social forestry extension training program which has been supported by JICA since 1995.

Kenya, in this background, requested to Japan a technical cooperation on capacity development for sustainable forest management.

With development cooperation mentioned above deployed in the field of forest and forestry in Kenya, it is requested, in the context of achieving the national forest cover target of 10%, to set to capacity development of officers in country governments which have taken a role of forest extension as part of decentralization, and to capacity development of policy making and administration for the officers in Ministry of Environment and Forestry (MoEF), KFS and relevant organization.

In response to the request, a new technical cooperation has started in June 2016 for 5 years, which consists of 5 components such as support of forest policies, forest extension in ASALs, REDD+ readiness, tree breeding and regional cooperation in Sub-Sahara Africa. The purpose of the project is to strengthen the national and county government capacity for sustainable forest management toward achieving the national forest cover target of 10%.

1 the figure is based on the National Forest Reference Level (FRL) submitted to UNFCCC by Kenya Government.

1.2 Objective of the project

(1) Overall goal

Sustainable forest management is promoted in Kenya towards the national forest cover target of 10%.

(2) Project purpose

Capacity at the national and county level for sustainable forest management is strengthened.

(3) Outputs

1. Implementing and monitoring capacities of forest-related policies/strategies at the national level are enhanced.
2. Capacities of public and private sectors, and NGOs/CBOs to promote tree growing in ASALs are enhanced through forest extension activities.
3. Technical capacities for REDD+ readiness activities and forest monitoring for sustainable forest management in KFS are strengthened.
4. The capacity of breeding techniques for drought tolerant trees in KEFRI is improved.
5. Capacity of regional cooperation in KEFRI is intensified by promoting knowledge sharing and transfer of technologies for strengthening the resilience to climate change and drought in Sub-Sahara Africa.

1.3 Period of the project

5 years, from June 2016 to October 2021 (5 years and 4 months)

Entrusted Period of Tree breeding (Output 4) to FTBC is from September 2017 to October 2021(4 years and 4 months).

1.4 Implementation agencies

Ministry of Environment and Forestry (MoEF), Kenya Forest Service (KFS), Kenya Forest Research Institute (KEFRI) and County Governments

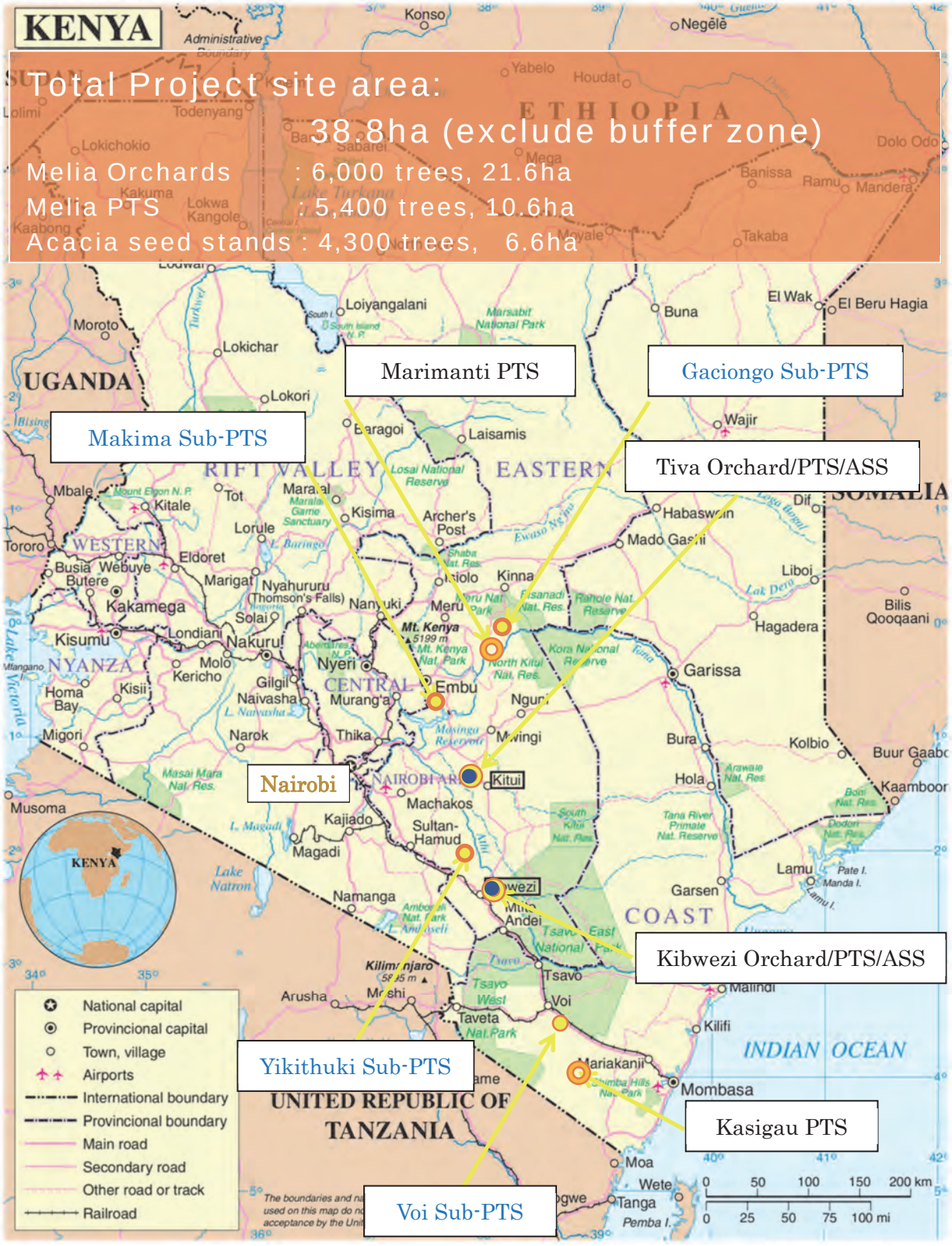
2. Purpose of work

Forest Tree Breeding Center, Forestry and Forest Products Research Institute (FTBC, FFPRI) is responsible to the output 4 of the project “The capacity of breeding techniques for drought tolerant trees in KEFRI is improved”. C/P Institution of this work is KEFRI.

This work takes a follow up of the previous tree breeding project “Project on development of drought tolerant trees for adaptation to climate change in drylands of Kenya” which was finished at July 2017 and also implement a new research activity as artificial crossing of Melia for making of second generation to contribute to improvement of capacity for tree breeding research in KEFRI.

3. Target area of work

Main target areas of work are Tiva and Kibwezi where orchards and PTS were located.



Melia Orchard/PTS/Acacia Seed Stand PTS Sub-PTS

Chapter 2 Contents of activities

1. Basic Policy of activities

The previous tree breeding project "Project on development of drought tolerant trees for adaptation to climate change in drylands of Kenya (2012～2017)" implemented analysing genetic variation, tree breeding research, developing propagation techniques and drought tolerance research through introducing advanced breeding technology. Based on these works, CADEP component 4 started an advanced research activity for producing *Melia volkensii* second generation of plus trees which would complete a cycle of tree breeding. The final goal of the work is to build a breeding research ability to accomplish the breeding cycle.

(1) Tree Breeding

Tree breeding in Kenya has been on the first stage with 2 Melia seed orchards[*1] and its 12 progeny test sites[*2] established in the previous project as a base for research activities. Data collection from the test sites begun and has been continuously implemented.

The main activity in this project was therefore to provide a guidance on proper data collection in the progeny test sites and accurate analysis to select excellent trees, which would allow KEFRI staff to proceed in making second generation. This was to contribute to stepping-up their research ability by acquiring a capacity to accomplish an entire research cycle of tree breeding.

Another activity on breeding was for *Acacia tortilis* which followed the activities for Melia based on collection of data from 2 Acacia seed stands[*3]. Technical guidance was provided for Acacia seed stand management, to maintain the seed stand healthy and appropriate for efficient seed production.

(2) Propagation techniques

In the former project, grafting technique of Melia has been established and transferred to KEFRI staff. Cutting propagation technique, however, has not been established completely though it was an important technique to reproduce superior clones and thus establish a seed orchard efficiently. Therefore, some experiments of cutting have been implemented and some of them was successful. Same work for Acacia was also conducted.

(3) Artificial crossing of Melia

A study on artificial crossing of Melia to produce its next generation. This was to cross entomophilous flowers of Melia, which had been thought to be a challenge. Flowering phenology and characteristic of seed production, as basic data collection, were studied first and study on pollen collection and preservation was also implemented.

(4) Drought tolerance

Some candidate clones as drought tolerant trees had been selected through several experiments in the former project. Detailed investigation was conducted to develop indices on drought tolerance by the team of Kyushu University.

(Reference)

＊１：*Melia Volkensii* orchards were established in Tiva (Kitui) and Kibwezi (Makueni) in2012, 2013 and 2014, which has totally 6,000 trees, 21.6ha.

＊２：Progeny test sits(PTSs) were established in 2014, and 2015 at 12 different sites across four agro-ecological zones in Gaciongo, Marimanti, Makima, Tiva, Yikithuki, Kibwezi, Voi, Kasigau, which has totally 5,400 trees, 10.6ha.

＊３：*Acacia tortilis* seed stands were established in Tiva and Kibwezi in 2015 and 2016, which has totally 4,300 trees, 6.6ha.

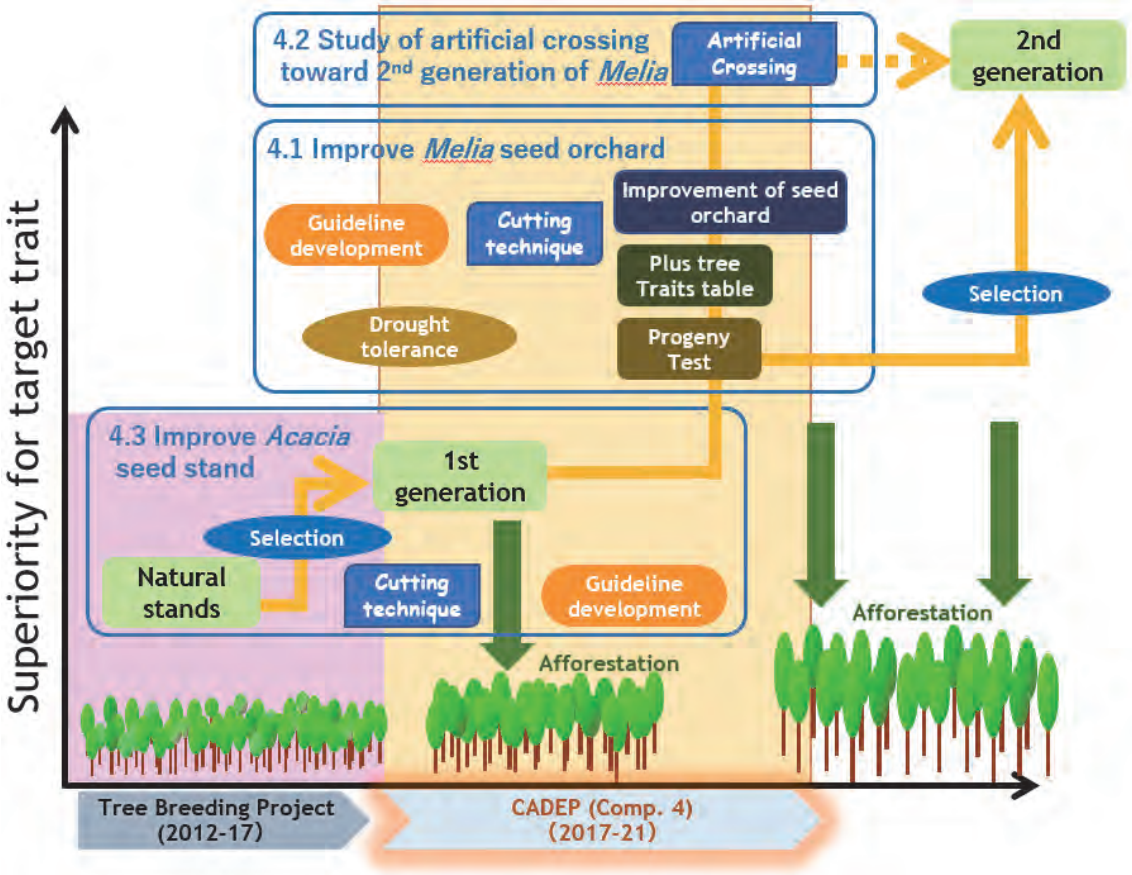


Figure OP 4-1: Flow Chart of Tree Breeding on Melia and Acacia

2. Implementation of activities

2.1 (Activity 4-1) Improve the quality of clonal seed orchard of *Melia volkensii*

This activity aimed at improving the quality of clonal seed orchards of Melia through selection of excellent plus trees based on drought tolerance indices and progeny test site data analysis.

4-1-1 Development and application of drought tolerance indices related to the growth of Melia

a. Comparison of the growth of superior and inferior clones selected from Candidate Plus Trees (CPTs) –seed orchard in Tiva and Kibwezi

In 2017, the seasonal stem growth patterns of superior and inferior clone were compared. The superior clone continued its growth under water stress, with the stem shrinkage smaller than that of the inferior clone. This result suggested that superior clone has some physiological features to reduce the effect of water stress. There was a possibility of related parameters being developed as indices for plus tree selection of Melia.

In 2019, stem volume growth of plus trees planted at Tiva and Kibwezi seed orchards was compared. There was a significant positive correlation between the volume each family has in Tiva and Kibwezi. This result suggests that the selected superior or inferior clone has a genetically high or low growth ability. There was also a significant positive correlation between stem volume of 2 years and 7 years old. This result suggests that we can select the superior clone in young stage.

b. Comparison of physiological features of superior and inferior clones selected from Candidate Plus Trees (CPTs) – nursery in Kitui center

In 2017, the light-photosynthesis curve and leaf chlorophyll content of the superior and inferior plus tree growing at Kitui nursery investigated.

There was an obvious difference among maximum photosynthesis of each clone, which was from 9 to 18 μmol $CO_2/m^2/s$.

However, the photosynthesis of superior clone was not necessarily larger than that of inferior clone, nor a remarkable difference among leaf chlorophyll contents.

Figure OP 4-2: Measurement of photosynthesis

c. Development of drought tolerance indices related to the growth of Melia

Characteristics of Melia seedling grown from open seeds of superior and inferior clone were studied from 2018 to 2020. Tree height (H) of superior clone was a little lower than that of inferior clone and the stem diameter at ground level (D) of superior clone was a little larger than that of inferior clone. As a result, the H/D ratio of superior clone was smaller. There was a possibility that H/D ratio of seedling were an available index for selecting the Melia plus tree.

Figure OP 4-3: Comparison of the shape of superior and inferior

d. Classification of Candidate Plus tree into different drought tolerance levels

The superior clone seemed to have characteristics which were related to drought tolerance. In this regard, measurement of the morphological features related to drought tolerance by using seedlings from selected plus trees was conducted. Seedlings from 36 clones were compared, and the H/D ratio of superior clones was smaller than that of inferior clones. The result suggested that smaller H/D clone tended to more widespread in growth and that D was bigger in fast-growth clones. Consequently, the H/D ratio of seedling seems to be an available index of drought tolerance for selecting the plus tree of *Melia volkensii.*

4-1-2 Evaluation of traits of plus trees

a. Assessment of PTSs

In 2017-2020, the assessment of PTSs is implemented by KEFRI principally twice a year in Jan-Feb. and Jul-Aug. In 2018, short term experts made lectures to improve the capacity of trait measurement in PTS assessment, such as measurement procedure for indexing fecundity, healthiness, and stem form of Melia in PTS. By these lectures, the capacity of C/P in terms of data aggregation technic on research activity was strengthened.

b. Data analysis

b-1 Data analysis

FTBC input the assessment data on Feb. & Aug. 2018 into data file, and has carried out detailed analysis. Through the analysis on growth and seed production, superior clones showing both superior growth and good seed production were identified.

The results of breeding were as follows:

a) There was a significant growth variation among families, despite of large between- and within- site growth variation.

b) Based on the breeding analysis, performances of both growth and seed production were thought to be improved in the future.

c) The progenies of “good” families always showed faster growth across sites.

In 2021, KEFRI input the assessment data on June 2021 into data file. FTBC and KEFRI analysed the data for genetic evaluation of plus trees for preparation of plus trees traits table.

b-2 Training

Short term experts delivered lectures for data analysis of PTS assessment to KEFRI researchers, using common data analysis software on Dec. 2018 and Aug. 2019. These seminars should be of an intermediate level, which

aimed at strengthening data aggregation technic, statistics analysis and drawing figures on forestry research activity. FTBC and KEFRI shared the statistical analysis scripts for the evaluation of plus trees to enhance data analysis techniques for the subsequent data sets.

Figure OP 4-4: Training for data analysis of PST assessment

b-3 Plus tree traits table

In 2020 FTBC and KEFRI analysed growth and other traits using the data obtained in PTSs and seed orchards, calculated breeding values and clonal values for each plus trees. FTBC and KEFRI compiled the result and developed a draft of plus tree traits tables.

In 2021, FTBC created the latest 'Plus tree traits table of Melia' based on 2021 PTS assessment (5th year) data which was sent by KEFRI.

Though the H/D ratio of seedling derived from orchard open pollinated seeds seemed to be an available index of drought tolerance in Activity 4-1-1, it was not incorporated in 'Plus tree traits table of Melia', because the correlation between the H/D ratio and the latest PTS assessment data was not identified.

b-4 Selection of 2nd generation based on breeding values

FTBC and KEFRI selected 400 individuals of 2nd generation Melia. This activity was an advanced progress beyond the scope of CADEP.

On Dec.2019, short term expert and C/P took a step toward selection for next-generation, based on PTS assessment data with a lecture on the latest breeding analysis method.

According the capacity development activity [4-1-2a: assessment of PTSs], C/P of KEFRI had collected abundant data of multiple traits of Melia, including stem height, diameter, volume, stem form, fecundity and healthiness. Using these data of multiple traits, a selection which would improve multiple traits simultaneously had implemented.

FTBC and KEFRI analysed the PTS data and estimated genetic performance of Melia trees in PTS. The order of prioritizing traits in ranking families were; 1. volume, 2. stem straightness and healthiness, 3. fecundity. Meanwhile it was considered to select progenies in a way that the estimated genetic performance in each trait were kept as high as possible.

FTBC also advised that it was important to balance improving multiple traits and keeping genetic diversity as wide as possible because the original breeding population size of *Melia volkensii* had been relatively small (100 CPTs of 1st generation).

With the principles above, KEFRI and FTBC researchers selected about top 10% trees in each PTS. These selected individual trees were marked with yellow paint. (Figure OP 4-5)

These activities were followed by discussions on a future Melia breeding plan setting up breeding population of 100 2nd gen individuals in each of 4 eco-regions (400 in entire Kenya), which were thought to be manageable breeding genetic resources in Kenya.

Figure OP 4-5: Selected 2nd generation trees with marking by yellow paint.

c. Guidance on maintenance measures of PTSs

c-1 Efficient weeding

In 2017 and 2018, FTBC and KEFRI discussed how to implement efficient weeding on seed orchards and PTSs. FTBC suggested introducing bush cutters with engine, and accordingly the director of Kitui regional center requested a purchase of the machines. In 2019 and 2020 weeding on each site was properly implemented.

c-2 Monitoring of all PTSs

In 2017-2020, a staff of site management monitored all sites including seed orchards and PTSs to check weed or any problems such as pests and diseases and reported the result to the chief advisor.

4-1-3 Improvement of seed orchards through rogueing

a. Stem cutting and branch pruning

In 2019, the methods of stem cutting and branch pruning in seed orchards are discussed.

b. Rogueing

In 2019, short term experts of FTBC lectured and proposed several ways of improving the "quality" of seed orchards in terms of tree breeding. Based on the results of the activity 4-1-2 [Evaluation of traits of Plus trees], a plan of rogueing of inferior Melia clones was planned.

In May 2020, FTBC and KEFRI made a meeting to improve seed orchard quality. According to the technical guidance of FTBC, inferior clones in seed orchards were planned to be rogued on May to Oct. 2020. However, it was hard to do that due to COVID.

In 2021, FTBC presented way of rogueing based on the trait table - result of statistical analysis in PTSs. FTBC and KEFRI discussed the future plan of rogueing and concluded to implement in the near future.

4-1-4 Development of a manual for maintenance of seed orchard

a. Development of manual

In 2021, KEFRI and FTBC prepared a maintenance manual of Melia seed orchard, the contents of which were selection of plus trees, establishment of clonal seed orchards, reducing pests and diseases, weeding and seed production.

b. Technical support

In 2017, FTBC provided a cracker for walnut for efficient removal of seeds from Melia fruits or nuts. It was tested to split or crack Melia nut but was found not successful and need to be improved, still it could be used for Melia

green fruit to get seeds.

4-1-5 Study on clone propagation technique for Melia

a. Technical support

a-1 Cutting

From2017 to 2020, FTBC has supported development of cutting propagation technique on *Melia volkensii*. The study was carried out for specified clones and period to establish the technique. FTBC took a pre-test study on cuttings of *Melia azedarach,* a native tree species of the same genus in Japan. FTBC introduced some measures based on the study.

In 2018, three trials of *Melia volkensii* cutting were implemented using sand medium. The trials used scions collected from green branches and young sprouts in Tiva seed orchard. One of the trials were conducted in an appropriate time of the year (1 month after the beginning of Rain season), however, neither callus formation nor rooting could be confirmed. The other trials showed the same results.

Another two trials of Melia cutting were implemented in 2019. One of the trials was conducted based on the difference in the medium (old-cocopeat, sand and pumice). After 6 months, one of the scions (coco peat, no IBA) was rooting. In 2020 Melia cutting trail suspended due to the Pandemic.

Through the plural trials above rooting was confirmed in only one scion. More study will be needed to produce clones for efficient seed orchard establishment.

Figure OP 4-6: Scions from green branches (Apr. 2018)

Figure OP 4-7: Rooting scion (Feb. 2020)

a-2 Air layering

Short term experts tried air layering/marcotting to Melia in Kenya as the cutting test was not successful. Air-layering / marcotting method trial was done in Tiva seed orchard in November 2019 with 24 branches of several mother trees selected randomly. It was done quickly as C/P of KEFRI were skilled at air-layering, having experiences and necessary equipment for air-layering, but the result was confirmed not successful in 2021.

b. Development of clone propagation manual

A "Guidelines for clone propagation of *Melia volkensii*" was made. The contents were grafting and other clonal propagation technique.

(Outcome of activity 4-1)

In 2021 the following guidelines were compiled.

- Plus trees traits table on *Melia volkensii* in the drylands of Kenya
- Manual for managing Melia seed orchards

- Guidelines for clone propagation of *Melia volkensii*

2.2 (Activity 4-2) Study of artificial crossing towards second generation of *Melia volkensii*

This activity aimed to implement a basic study on crossing of *M. volkensii* in the seed orchards towards the second generation, including study of phenology

4-2-1 Study on mating system

a. Phenology

Observation of seed orchards for study on phenology was carried out from 2017 to 2020, from Aug. to Sep. and from Feb. to Mar. every year. The observation confirmed large variation among clones in phenology. In addition, nuts/seed production capacity of Tiva and Kibwezi seed orchards was investigated. Seeds have been collected three times a year since 2016, and fruiting were observed in almost all mother trees in 2017. In 2019, flowering in full bloom was observed throughout the both seed orchards.

b. DNA analysis for mating system

In 2017, short term experts of FTBC lectured several scientific approaches for producing next generation including artificial (hand) pollination, open pollination and within-tent pollination system.

In 2018, seed sampling for DNA analysis started but the germination rate was not sufficient. In 2019, 10-15kg of fruits were collected from 2 blocks of Tiva, however, the germination rate was about 30% which was still not enough for analysis. In the next season, more seeds collected and germination rate reached 60%, which finally provided 480 seedling samples from 10 mother trees.

In 2019 to 2020, DNA extraction from germinated seedlings was conducted by C/P. The extraction started in Dec. 2019 and materials were prepared in 2020. FTBC provided C/P with technical guidance of analysis so that DNA genotyping by using Simple Sequence Repeat (SSR) marker would be carried out. However, analysis delayed due to inadequate supply of consumables during COVID pandemic, and finally the planned DNA genotyping by SSR marker was not accomplished.

4-2-2 Study for effective methods of artificial crossing

a. Collection and preservation method of Melia pollen

Study on preservation of Melia pollen was conducted using a phial with silica gel. Artificial crossing was conducted to confirm the viability of stored pollen in Tiva orchard in 2018 through guidance of a short-term expert. The experiment found fruit production very low, suggesting that the collection of Melia pollen seemed to be possible but as difficult as known for other tropical tree species.

b. Searching effective methods of artificial crossing

Study for effective methods of artificial crossing was designed by C/P according to advises by short-term experts. In order to confirm self-fertilization, a bagging experiment at Tiva orchard was implemented since 2018. Unopened buds in inflorescence were covered with mating bags to prevent contamination of pollen from other trees by small insects. Pollen was collected from stamen and reserved in a bin, and then applied to pistil of another clone using a fine brush. After brushing, the pistil was covered by a mating bag to prevent contamination by other pollen. The fruit production was observed as being low level, suggesting that artificial crossing was technically possible, but actually not as its efficiency relative to labour (bagging inflorescences, collecting pollen from father clones, and conducting hand pollination to mother clones) was quite low.

According to the results of trials, short term experts of FTBC and C/P of KEFRI discussed that the open

pollination system seemed to be better in terms of the efficiency - cost (labour, budget and time) balance - for producing next generation Melia.

Figure OP 4-8: Observation of processing on artificial crossing

(Outcome of activity 4-2)

Through these technology-transfer activities by short-term experts, the capacity of pollen collection and artificial crossing technique have been strengthened so that the mating experiment can be independently designed and conducted by C/P. In addition, the capacity of C/P to study mating system via genetic experiment was also strengthened. In 2021 Guidance of crossing technique towards second generation of *M. volkensii* was compiled.

2.3 (Activity 4-3) Improve the seedling seed stands of *Acacia tortilis*

This activity aimed at improving the seedling seeds stands of Acacia through selection of excellent plus trees based on data analysis of progeny test sites.

4-3-1 Assessment of PTSs

In 2017-2020, the assessment was to be implemented twice a year on Jan-Feb. and Jul.-Aug., but actually done on Aug. 2017, Feb. 2018, Aug. 2018, Sep. 2019, Mar. 2020 and Mar./May. 2021.

4-3-2 Data analysis and evaluation of traits of plus trees (1st-4th year)

From 2017 to 2019, KEFRI staff filed the assessment data from PTSs with assistance from FTBC. FTBC analyzed the data and gave a guidance to C/P. Traits on each family were evaluated with the data at the 2nd year after planting.

Growth of each family in the stands had been generally good and it was difficult to evaluate and differentiate superior (plus) trees and inferior trees. Upon this, improvement of the stands was planned to remove the trees systematically, not individually, felling trees on a diagonal line and leaving the ones on an adjacent diagonal line, and so on, choosing the lines so that the volume of remaining trees would exceed that of removed trees.

In 2019, FTBC discussed with KEFRI C/P how to assess the quality of Acacia wood. Upon the discussion, wood density was measured first, then carbon stock per tree was estimated from stem and branch weight in addition to digging up and weighing root biomass. The result of the research would contribute to the estimation of Green Carbon in planting activities.

In 2020-2021, apart from the thinning below, wood properties (density) data was collected using an equipment “pilodyn” as well as the measurement of woody biomass. 15 trees were selected per site five each from fast growing, medium growing and slow growing families. The total usable biomass collected and weighed per tree (figure 4-11). Disk samples were collected for carbonization and energy property tests.

4-3-3 Improvement of seed stands (Thinning of trees)

In 2018 the trees in Acacia seed stand showed very good performance, grew to self-standing stage. Upon that thinning of trees was planned by Dr. Ndufa (then Director of Kitui center) and short-term expert to implement in Aug. to Nov. 2019 for stands-2015 and in the end of Nov. 2019 for stands-2016. However, the thinning was postponed to the following year due to the early started and prolonged rainy season in 2019 and so again due to the following COVID-19 pandemic.

In 2020 lighting condition of the branches of Acacia became unfavourable due to overgrowth. Making more space between trees was thought to be urgent issue despite covid-19 outbreak in Kenya. Upon this, in Nov. 2020 thinning was carried out in a way planned in 4-3-2 for the 2015 stands in Tiva and Kibwezi. 250 trees were removed diagonally to half the trees in Tiva and 324 trees from Kibwezi site. The thinning of 2016 stands was done in March 2021 by the same method (figure 4-9,4-10). Promoting Acacia flowering is expected by the thinning.

While thinning was carried out as above, flowering condition continued to be low. FTBC and KEFRI discussed to postpone stand improvement to the year after 2022, when sufficient flowering would enable evaluation of fecundity.

Figure OP 4-9: Felling and clearing -Tiva

Figure OP 4-10: Cleared floor - Tiva

Figure OP 4-11: Weighing samples

4-3-4 Study on clone propagation technique for Acacia

Development of clonal propagation technique is required to establish next generation Acacia seed orchard.

A trial on grafting method of Acacia was done in 2018 using scions collected from 5-year Acacia in Kitui nursery with instructions from short term expert to select and prepare scions. However, the result was not satisfying. Another trial on grafting was done in 2019 using scions from three better growth families on Tiva seed stand. The grafts were kept under cheesecloth, watered twice a day (AM/PM), which were basically the same way as these with Melia. The result was not good again.

In 2019 'Fukurotugi' method (bark grafting) which never tried before for Acacia was carried out in November 2019. The grafts were kept under cheesecloth in Tiva nursery. However, the result was not good. More study will be necessary to realize clone propagation of Acacia for establishing next generation efficiently. All the while, KEFRI staff already understood the grafting method so technical transfer was thought to be achieved.

Figure OP 4-12: Grafting by KEFRI staff (Jan. 2018)

Figure OP 4-13: Grafting Guidance (Nov. 2019)

(Outcome of activity 4-3)

The seedling seed stands showed good growth despite poor flowering. The biomass measurement will give an important information for its fuel usage. Stand thinning will pave towards healthy stand condition and better flowering in the near future which will be assessed and evaluated. The clone propagation was found not successful with current grafting methods. In 2021 Guideline for establishment and Management of *Acacia tortilis* Seed Stand in Kenya was compiled.

2.4 General work

FTBC couldn't dispatch the short time expert continuously due to COVID-19 pandemic since Mar. 2020. In this satiation, FTBC maintained close contact with KEFRI and chief adviser of project for monitor the progress of activities so that FTBC implemented the project activities efficiently.

(1) Making of work plan (2017-20220)

FTBC made basic policy of activities in accordance with the Record of Discussion and Minutes of Meeting on the project. And according the analysis of the result on the former tree breeding project, FTBC made a work plan and finalized it taking account of comments from Global Environment Department of JICA and chief adviser of project. FTBC explained the work plan to KEFRI, JICA Kenya Office and long term experts and it was authorized in Kenyan and Japanese sides.

(2) Attendance to meetings concerned

FTBC participated the following meetings and makes necessary discussion with staff concerned.

a. JCC

- Joint Coordination Committee Meeting held on 5th Dec. 2017
- Joint Coordination Committee Meeting held on 19th July. 2018
- Joint Coordination Committee Meeting held on 21th Feb. 2019
- Joint Coordination Committee Meeting held on 28th Jan. 2020
- Joint Coordination Committee Meeting held on 14th Sep. 2021 (as an online attendee)

b. PMU

- Project Management Unit meeting held on 27th Nov. 2017
- Project Management Unit Meeting held on 23rd May. 2019
- Project Management Unit Meeting held on 26th Jan. 2021 (as an online attendee)
- Project Management Unit Meeting held on 3rd Sep. 2021 (as an online attendee)

c. Seminar

- Melia promotion seminar held 16th May. 2018(Component 2)

d. Workshop

- CADEP project interaction workshop held 26th Jun. 2018
- CADEP project interaction workshop held on 23th Jul. 2019 in Kitui

e. Online meeting with C/P

- KEFRI-FTBC experts (3 from KEFRI, 7 from FTBC) had an online meeting with 3 long-term experts and a JICA Kenya officer on 15 February 2021. They confirmed the progress and future activities in the latter half of the 4th year and the former half of the 5th year.
- KEFRI-FTBC experts had an online meeting on 26th Apr. 2021. They confirmed the progress and future activities.
- KEFRI-FTBC experts had an online meeting on 1st Jul. 2021. They confirmed the schedule of making Guidelines.
- KEFRI-FTBC experts had an online meeting on 6th Aug. 2021. They confirmed the progress and future activities, especially rogueing of Melia orchards and PCR.
- KEFRI-FTBC experts had an online meeting on 30th Aug. 2021. In the meeting FTBC lectured on rogueing of Melia.

(3) Monitoring

- FTBC made a monitoring sheet in accordance with the "Monitoring procedure for technical cooperation" with C/Ps and submitted it to the chief advisor. Items for the monitoring include activities implemented, specific results, subjects to be solved and external factors that could influence the progress of the project activities or results, and the items were confirmed and recorded for the sheet by FTBC and C/Ps. It was submitted to Chief Adviser of Project August and February every year.

(4) Implementation report

- FTBC made an implementation report on Feb. every year and submitted it to JICA.

(5) Publicity works

FTBC attempted more effective publicity works so that the activities of this work are better understood around Kenya and abroad through sending information concerned on web-sites in Kenya or releasing results of research activities at an academic meeting and publications on and out of Kenya. For example, Tree breeding project in Kenya was submitted on information Magazine of Forestry Agency "Rinya"

FTBC received 3 CPs from Kenya for training course and provided lectures on tree breeding and distribution system of improved seed and seedling in Japan on Nov. 2017.

(6) Implementation and progress management of work【**Appendix 5-1-1～8**】

(FY. 2017)

- Project coordinator was dispatched to attend PMU and JCC meeting and explained activities on tree breeding of Component 4 for 4 years on Nov.2017.

(FY. 2018)

- Project coordinator was dispatched to talk about an annual budget for tree breeding activities on component 4 with CPs and chief advisor, and support a study on propagation technique on Apr. 2018.
- Project coordinator was dispatched to attend Melia promotion seminar, and observe Melia plantation by a private sector, which has a plan to make a Melia seed orchard on May 2018.
- Project coordinator was dispatched to attend CADEP component workshop on Jun. 2018.
- Project team leader and coordinator were dispatched to attend 6th JCC meeting on Jul. 2018.
- Project coordinator was dispatched to talk about tree breeding activities on component 4 with CPs, and conduct a study on Melia cutting on Nov. 2018.
- Project team leader and coordinator were dispatched to discuss the component activities with JICA mid-term review team, and attend 7th JCC meeting on Feb. 2019.

(FY. 2019)

- Project coordinator and expert were dispatched to talk about an annual budget for tree breeding activities on component 4 with CPs and chief advisor, and attend project management unit meeting and observe Melia plantation by a private sector, which has a plan to make a Melia seed orchard on May. 2019.
- Project coordinators were dispatched to attend the 2nd Interaction workshop on Jul. 2019 and attend the meeting for collaboration between component2 and 4.
- One expert was dispatched to talk about tree breeding activities on component 4 with CPs, and conduct a study on Melia cutting and Acacia grafting on Nov. 2019.
- Team leader and coordinator were dispatched to discuss the component activities with CPs, and attend the 5th JCC meeting on Jan. 2020.
- One expert was dispatched to talk about tree breeding activities on component 4 with CPs, and conduct a study on Melia cutting and Acacia grafting on Feb. 2020.

(FY. 2020)

- FTBC team have not been to Kenya since March 2020 because of spreading COVID-19. For this reason, they confirmed the progress of activities by e-mail and web meeting

(FY. 2021)

- FTBC team have not been to Kenya since March 2020 due to continuously COVID-19. For this reason, they confirmed the progress of activities by e-mail and web meeting

Chapter 3 Challenge and Lessons learnt

1. Challenge and lessons learnt on implementation

1.1 Method of implementation activities

Forest Tree Breeding Center (FTBC) has provided latest technologies of breeding in “Project on development of drought tolerant trees for adaptation to climate change in drylands of Kenya (2012～2017)” and delivered technical guidance and supports such as analyzing genetic variation, tree breeding research, developing propagation techniques and drought tolerance research.

FTBC conducted capacity development on breeding research ability of KEFRI researches with seed orchards and progeny test sites established so ever and knowledge found in the former project. Notably, for *Melia volkensii* we started a new research activity such as clone propagation and artificial crossing for producing Melia second generation of plus trees and show a cycle of tree breeding so that KEFRI would acquire breeding research ability with which it could continue the breeding cycle.

(1) Tree Breeding

In the tree breeding project of Melia in Kenya, foundation of breeding activity, namely, launching 2 seed orchards and 8 progeny test sites, evaluation of genetic diversity of the target population and making relevant guidelines, had been accomplished as well as data collection from the test sites had begun in the former project. Following this, majority of the data from the orchards and PTSs was collected in the current project. Based on these progress, KEFRI acquired advanced techniques in tree breeding such as trait analysis with newly collected data in the PTSs and forwarding targeted population to second generation, with the assistance from FTBC researchers, so that KEFRI can implement tree breeding program for generations independently. The capacity of C/P and level of research work were augmented to more elevated stage.

Such breeding guidance was conducted based on scientific data promoted C/P understanding and activities, especially in the selection of Melia second plus trees from PTSs and improvement of orchard using trait table prepared from data of PTSs. Lectures on data analysis for PTS assessment using free, common data analysis software were delivered to KEFRI researchers by FTBC short term experts.

Regarding *Acacia tortilis*, the seedling seed stands growth assessment and establishment of the basis for plus tree seed production were carried out based on research experience from Melia. The thinning work in the seedling seed stands was conducted properly by C/P themselves with remote guidance from Japanese experts under pandemic, together with wood density and biomass measurement.

(2) Propagation techniques

Grafting technique of Melia has been established and transferred to KEFRI staff in the former project. Cutting technique, however, has not been established completely while cutting is an important propagation technique to produce superior clones and establish a seed orchard efficiently. Some experiments of cutting have been implemented earlier and some of them confirmed successful.

A result of pre-test study on cuttings with *Melia azedarach,* a native tree species of the same genus in Japan was introduced to CADEP aiming to establish cutting technique of *Melia volkensii*. C/P went through training of the method from preparation to execution of cutting so that they can implement the work independently. However, during COVID-19 outbreak, studies on cuttings and rooting of *Melia volkensii* was carried out in the green house in Hitachi, Japan by FTBC staff. There has been not enough result but a few successful cases which should be reflected to future work in Kenya.

As clone propagation technique of Acacia has not also been established, development of technique of clone propagation such as cutting and grafting were conducted taking account of necessity for future establishment of orchard.

(3) Artificial crossing of Melia

A study on artificial crossing of Melia to produce its second generation was implemented. As this study was unprecedented examination on artificial crossing of entomophilous Melia flower, research work started with observation of phenology and characteristic of seed production as basic data collection were conducted as a first step and study on mating system and artificial crossing followed.

(4) Drought tolerance

Some candidate clones have been selected as drought tolerant through several experiments in the former project. Taking over these results, selection of the drought tolerant clones with drought tolerance criteria were challenged by Kyushu University team. Although the team was not dispatched in the 4th and 5th year under COVID-19, it analyzed the existing data and provided the appropriate result.

1.2 Management Policy

(1) Coordination of C/P and short term experts

For component 4 (Tree Breeding) of the project, the technical guidance to C/P and relevant site investigation was implemented by dispatching short term experts from Japan. It is, therefore, significant for C/Ps to take an appropriate coordination with experts before carrying out the activities. Monitoring of the all sites was implemented by C/Ps who were appointed as a Regional Director of Kitui and an officer in charge of Kibwezi, to check and investigate the situation of all seed orchards and PTSs. The result of monitoring was informed to all staff concerned. It was considered that this contributed much to enhance C/P's ownership for the project activities.

(2) Coordination with Japanese experts

FTBC coordinated the work with the chief advisor and C/Ps so that all tree breeding activities for component 4 were implemented adequately and efficiently. FTBC explained annual work plan to the JICA chef advisor and long term experts at the beginning of the year. The time of dispatching were coordinated with time of flowering of target species so that not to miss the appropriate time for work.

(3) Cooperation between researchers, technical staff and logistic staff

Organization framework of Kenyan and Japanese sides was developed to implement the tree breeding activities appropriately, as shown in next section. The data collected from the test sites was shared from KEFRI to FTBC and the Kyushu university team so that selection of excellent clones could be completed. All academic submissions were coauthored in scientific reports with Kenyan and Japanese researchers.

(4) Maintenance measures of Orchards and PTSs for Melia and Acacia

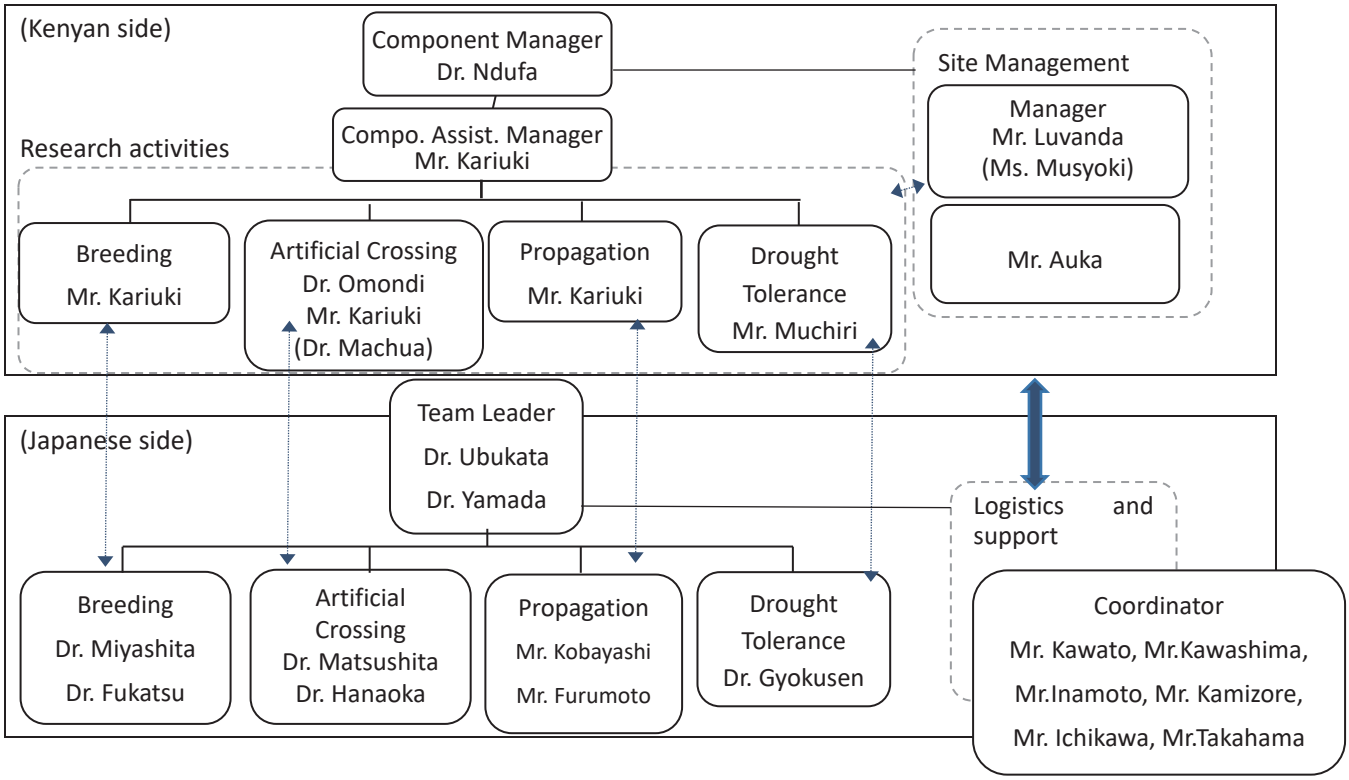
In this project, appropriate maintenance of the orchards, seed stands and PTSs established by former project were vital as its activities thoroughly depend on breeding data collected in these sites. C/P paid efforts for efficient and effective management of these sites under close cooperation of both short and long term experts.

(5) Activity for forest extension

Activity of component 4 is related to extension work done by component 2. Discussion and information sharing were done among experts of both components on the treatment of seedling and strengthening distribution system of seedling.

2. Management of operation

(Organization framework of Kenyan and Japanese sides)



3. Member of experts

Title	Name	Contents of work
Team Leader	Dr. Masatoshi Ubukata Dr. Hiroo Yamada	- Delegate short term experts for coordination with long term experts - Manage the progress of research activities - Suggest work plan - Coordinate writing reports
Tree Breeding	Dr. Hisaya Miyashita Dr. Eitaro Fukatsu Mr. Ryo Furumoto Mr. Yoshinori Takakura Mr. Shoki Sakamoto Mr. Nobutaka Chiba	- Guide suitable management of Melia seed orchard and PTS, Acacia seed stand and PTS - Analyze data from PTS and guides the methodology - Select plus trees according to the PTS analysis - Study on cutting of Melia - Study on propagation of Acacia - Guide stem cutting and branch pruning of Melia on seed orchard - Guide managing technique of Acacia seed stand
Artificial crossing/ Second generation	Dr. Michinari Matsushita Dr. So Hanaoka	- Study on phenology of Melia flowering - Study on crossing of Melia - Analyze DNA - Study on collection and observation of pollen of Melia - Study on artificial crossing method
Drought Tolerance	Dr. Koichiro Gyokusen Dr. Kotaro Sakuta Dr. Michito Tsuyama Dr. Eiji Goto	- Check evaluation measures of drought tolerance - Conduct on morphologic and physiologic survey - Develop index of drought tolerance - Selects drought tolerant individuals
Coordination/ Project Management	Mr. Hideki Kawato Mr. Yutaka Kawashima Mr. Tatsuo Inamoto Mr. Shizuo Kamizore Mr. Hidetaka Ichikawa Mr. Taiki Kobayashi Mr. Yoshiki Takahama	- Make work plan - Coordinate the work with C/P and long term experts - Manage a budget concerned - Coordinate issues on JCC etc.

Chapter 4 Achievement of work

Dispatching short term experts to transfer techniques, FTBC maintained close contact with KEFRI, chief adviser and long term experts of project so that project activities such as research, development and techniques transfer would be implemented efficiently. Consequently, the project presented a good result and the capacity of C/P were strengthened. Activities on component 4 have been implemented smoothly along with the plan from 2017 to 2018. However, after outbreak of COVID-19 has occurred since Mar. 2020, FTBC did not dispatch experts to project sites and delivered advices to C/P by online meeting.

1. Achievement status of output

Indicator 4-1 "Plus trees of *Melia volkensii* and *Acacia tortilis* are selected in the seed orchards and stands in Tiva and Kibwezi."

<Almost Achieved>

FTBC and KEFRI researchers analyzed growth and other traits, and developed a draft of plus tree trait table for 1st generation plus tree of Melia. Subsequently, FTBC proposed KEFRI improvement of 1st orchards (1.5 generation) implemented by rogueing inferior Melia trees based on the plus tree trait table. KEFRI decided that rogueing would be conducted after fruits data on orchards acquired. For Acacia, thinning was implemented for improvement, while selecting of plus trees by evaluating Acacia trees using growth/flowering data has been partly implemented as due flowering was not observed. Therefore, indicator 4-1 was almost achieved.

In addition, FTBC and KEFRI researchers took a further step toward future tree breeding cycles in Kenya, and implemented the on-site selection of 400 individuals of 2nd generation Melia in entire Kenia (100 in each region). As the result of above improvement, it is estimated that 1.5 generation of Melia seed orchards would provide the 17 % improvement in stem volume and that second generation by selection of plus trees would provide 14 % improvement in stem volume.

Indicator 4-2 "Researchers of KEFRI acquire the skills of artificial crossing technique"

<Achieved>

Through technology transfer by short-term experts, the capacity of pollen collection and artificial crossing technique have been strengthened to a practical level for the mating experiment. In addition, genetic experiments such as DNA extraction and SSR genetic analysis were conducted by C/P for a study of mating system.

Therefore, acquiring the skills of artificial crossing technique for KEFRI researchers, indicator 4-2 was achieved.

2. Situation of activities

a. Improve the quality of clonal seed orchard of *Melia volkensii*

(4-1-1) Development and application of drought tolerance indices related to the growth of Melia

(Almost achieved)

Characteristics of Melia seedling grown from open seeds of superior clones (fast growth clones) and interior clones (slow growth clones) were studied and it was clear that the superior clones have characteristics of drought tolerance. The tree growth and leaf chlorophyll content of grafted seedlings of fast growth clones and

slow growth clones were measured. However, the photosynthesis of superior clones was not necessarily larger than that of inferior clones, nor a remarkable difference among leaf chlorophyll contents. Meanwhile, the H/D ratio of superior clones was smaller than the H/D ratio of interior clones. There was a possibility that H/D ratio of seedling was an available index for selecting the drought tolerant Melia plus tree. However, it was not incorporated in 'Plus tree traits table of Melia', considering the weak correlation with growth properties of the progenies. The growth examination of trees selected by criteria of H/D ratio remained a future challenge.

(4-1-2) Evaluation of traits of plus trees

(Achieved)

In 2017-2020, the assessment of PTSs was implemented by KEFRI principally twice a year in Jan-Feb. and Jul-Aug except Jul.- Aug 2020. It is estimated that the gain of growth improvement is 17% at second year after planting. In 2019 short term experts delivered lectures for data analysis of breeding to C/P and the evaluation of plus trees was implemented by C/P. Then C/P capacity for data analysis was strengthened. In 2021, the 'Plus tree traits table of Melia' was created based on the assessment data.

Beyond its original scope of work, superior Melia as 2nd generation were selected based on result of analysis of growth at PTSs and seed production survey of seed orchards. Subsequently the 2nd generation trees were marked by yellow paint in Kitui PTS.

(4-1-3) Improvement of seed orchards through rogueing

(Almost achieved)

In 2019, short term experts of FTBC provided a training program for data assessment method and lectured several ways of improving the "quality" of seed orchards in terms of tree breeding.

In May 2020, FTBC and KEFRI made a meeting to improve seed orchard quality. However, the implementation was difficult due to COVID-19.

In 2021, FTBC presented a way of rogueing of interior clones for improving Melia orchards (1.5 generation) based on the trait table - result of statistical analysis in PTSs. FTBC and KEFRI discussed the future plan of rogueing and concluded to implement it in the near future after fruits data on orchards acquired. FTBC also predicted 17% gain assuming 50% rogueing.

(4-1-4) Development of a manual for maintenance of seed orchard

(Achieved)

In 2021, KEFRI and FTBC prepared a maintenance manual of Melia seed orchard, the contents of which were selection of plus trees, establishment of clonal seed orchards, reducing pests and diseases, weeding and seed production, etc.

(4-1-5) a. Study on clone propagation technique for Melia

(Achieved)

In 2018, examinations of cutting propagation of Melia were implemented but neither callus formation nor rooting were confirmed. After that the examinations were implemented with different conditions for cutting part and medium, and only one rooting was observed. In November 2019, FTBC tried examination of air layering and failed

Since short term experts were not dispatched under COVID-19 outbreak in the 2020 and 2021, FTBC studied on cuttings and rooting of Melia in the green house in Hitachi and rooting was conformed in one case. A "Guidelines for clone propagation of *Melia volkensii*" was made based on these experiences.

4-2 Study on mating system and artificial crossing towards second generation of *Melia volkensii*

4-2-1 Study on mating system

(Achieved)

Regarding the observation of the mating system for identifying crossing variation among clones, observation of phenology and fruiting was implemented. C/P prepared seeds for seedling sampling for DNA analysis but germination rate was not sufficient. In 2019 to 2020, DNA extraction from better germinated seedlings was conducted by C/P. FTBC provided C/P with technical guidance of analysis so that DNA genotyping by using Simple Sequence Repeat (SSR) marker would be carried out. However, analysis delayed due to inadequate supply of consumables during COVID-19 pandemic, and finally the planned DNA genotyping by SSR marker was not accomplished. FTBC provided necessary support so as to KEFRI can resume work once the procurement fulfilled.

4-2-2 Study for effective methods of artificial crossing

(Achieved)

Studies on effective methods of artificial crossing to produce its next generation were conducted in Tiva orchard. The capacity of pollen collection and artificial crossing technique have been strengthened to a practical level for the mating experiment through technology transfer by short-term experts. However, judging from the result of the field exercise, short term experts of FTBC and C/P of KEFRI discussed that the open pollination system seemed to be better in terms of the efficiency - cost (labour, budget and time) balance - for producing next generation Melia.

4-3 Improve the seedling seed stands of *Acacia tortilis*

4-3-1 Assessment of seedling stands

(Achieved)

The assessments of two seedling stands of Acacia were to be implemented twice a year on Jan-Feb. and Jul.-Aug. But two assessments out of them were not implemented due to budget shortage and COVID-19 pandemic.

4-3-2 Data analysis and evaluation of plus trees

(Almost achieved)

The stands were thinned for wider spacing in 2020 Nov. and 2021 Mar. systematically along diagonal lines because the plus trees were not selected with regard to the result of growth assessment that showed generally good growth among trees. Still, in terms of improvement, thinning was planned so that the volume of the remaining trees would exceed that of trees removed. The thinning also would provide better flowering which could lead to the second thinning (selection). Wood density and biomass estimation stems, branches and their root from thinned was carried out. Energy property was also investigated.

4-3-3 Improvement of seed stands for Acacia

(Achieved)

In 2018 the trees in Acacia seed stand showed very good performance, grew to self-standing stage.

Therefore, KEFRI and short term experts discussed and decided that the stands need to be thinned. Following the method planned in 4-3-2, thinning was carried out in Nov.2020 for the 2015 stands in Tiva and Kibwezi and the trees were removed diagonally to half. The thinning of 2016 stands was done in Mar. 2021 at both sites by the same method.

4-3-4 Study on clone propagation technique for Acacia

(Achieved)

Development of clonal propagation technique were tested because the clone propagation technique of Acacia had not been developed. However, several trials on grafting method including 'Fukurotugi' (bark grafting) done in Feb. 2020 were not satisfying. FTBC and KEFRI concluded it is difficult to use clonal propagation technique for Acacia, which led to adoption of seedling seed stand method for the future (not clonal seed orchard using grafted scions).

Chapter 5 Recommendation for future

(1) Establishing local orchards

In order to expand activities of collaboration with the private sector supported in as component 2 of this project, KEFRI needs to support private company with techniques such as selection of proper clone and appropriate planning of Melia orchard if the private company prefers establishment of its own orchard.

(2) Selection of Melia plus trees

The Melia plus trees are selected through progeny test assessment in 2021, which was done far earlier than ideal stage of assessment namely the harvesting years of progeny (12th to 15th). It is desirable that the assessment should be conducted as young as 10th year to select plus trees with reference to the progeny test experiences in Japan.

(3) Management of orchards

FTBC and KEFRI have discussed the way of the management of seed orchards including necessary budgeting by KEFRI since the former project. FTBC provided KEFRI with technical advices on paper in Nov. 2018 for more financially efficient management of orchards. In 2018, it had been decided that KEFRI would increase its budget for more than 20% from the previous year, but KEFRI was unable to allocate the necessary budget and the orchards were maintained only with project budgets. After 2019, KEFRI prioritized expenditure on the employment of security for orchards, which led orchards and PTSs to be unweeded. It is advised that KEFRI secure necessary budget to manage the orchards properly.

(4) Continual engagement of relevant C/Ps

There was a risk that C/P or researchers left the project due to job assignments during the project period so that the transferred techniques would turn to be ineffective for project. Therefore, it is necessary that C/Ps should be maintained to engage in all the project terms.

(5) Cooperation with relevant authorities

Component 4 (tree breeding) is related to component 2 (extension) in terms of provision of improved seed and seedling for its plantation sector, and to component 5 (regional cooperation) in terms of transferring the techniques to neighbor countries. It was important to strengthen the cooperation with those components and implement activities while considering needs of them. Therefore, activities under component 4 were conducted having discussions with those relevant components. With the component 2, the expansion of provision of improved Melia seed/seedling and necessity of prospection of improved Melia seed demand were discussed. There were requests from private companies for provision of superior seed and sharing the information on growth trait of improved Melia. In order to realize these issues, the collaboration with KFS and relevant stakeholders including the private sector should be strengthened. As for regional cooperation, it is recognized that KEFRI has a leading role in technology transfer, so the project result should be the base for the technology transfer taking account of the situation of each country with close collaboration among officers engaging in regional cooperation and tree breeding staff in KEFRI.

○ Appendix

Appendix 1. Project Design Matrix (PDM)……28

Appendix 2. Flowchart of work……30

Appendix 3. Plan of work operation……31

Appendix 4. Location of Orchards/Stands and PTS……35

Appendix 5. Dispatched short-term experts……55

(Summary sheet of Activities, FY2017-2021)

(1) Appendix 5-1-1~8 Project Management…..57

(2) Appendix 5-2-1~7 Drought Tolerance……..137

(3) Appendix 5-3-1~6 Artificial Crossing…….176

(4) Appendix 5-4-1~8 Tree Breeding……251

Appendix 6. Extension activity……312

Appendix 7. Guidelines……315

Appendix 1: Project Design Matrix (PDM)

Project Title: Capacity Development Project for Sustainable Forest Management in the Republic of Kenya
Implementing Agency: MoEF (Ministry of Environment and Forestry), KFS (Kenya Forest Service), KEFRI (Kenya Forestry Research Institute) and County Governments
Target Group: Direct Beneficiaries: Staff of implementing agencies and collaborating organizations
Indirect Beneficiaries: Population of pilot Counties and activity areas of NGO/CBO/private entities in Output 2
Period of Project: June, 2016 – October 2021 (5 years and 4 months)
Project Site: Nationwide, and ASALs (Arid and Semi-arid Lands) for Output 2 and Output 4. Model Site: Embu County and Taita Taveta County are as Pilot Counties for Output 2.

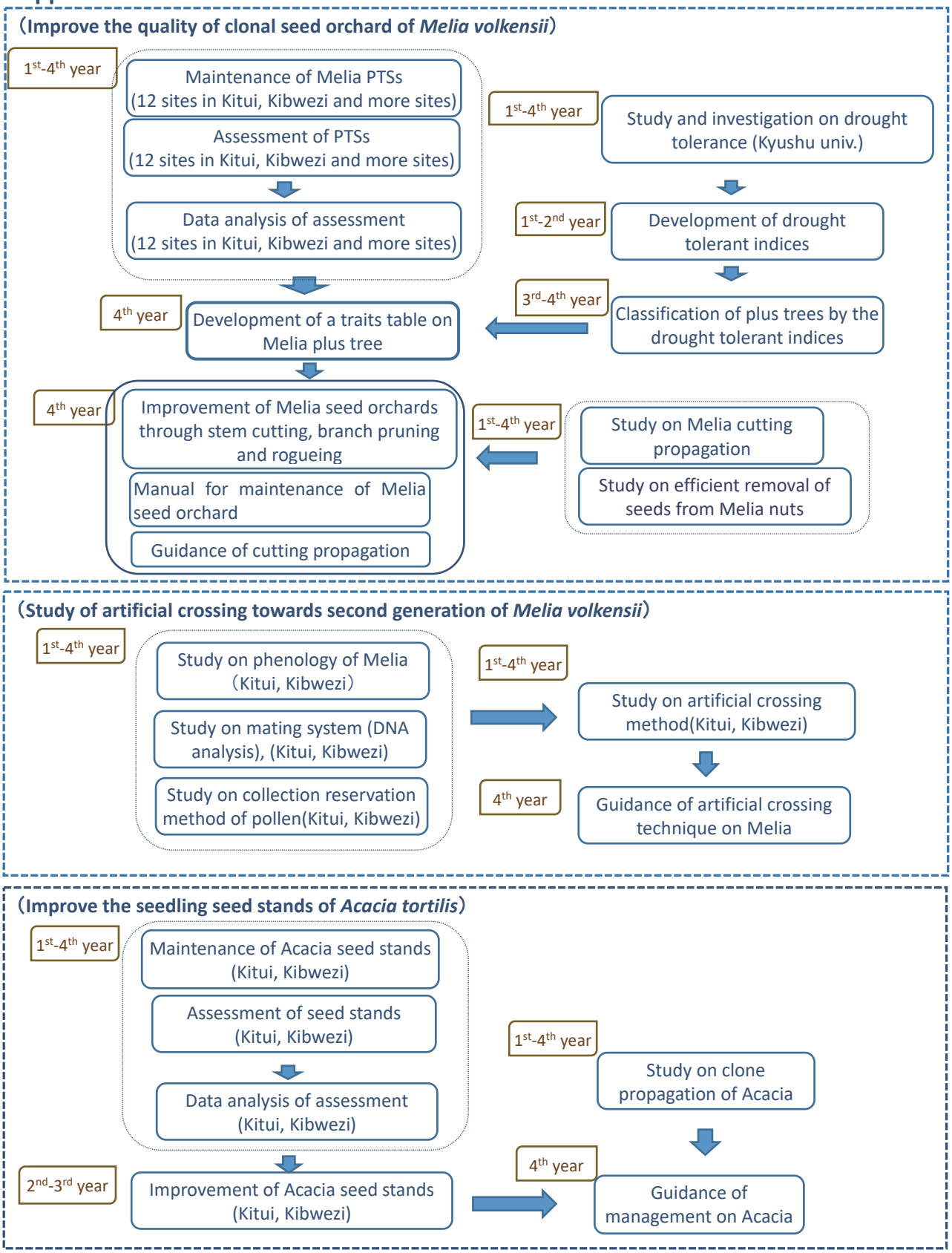
Version 4
Dated: Jan 28 2020

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal Sustainable forest management is promoted in Kenya towards the national forest cover target of 10%.	1 Monitoring by methodologies set in the NFMS (National Forest Monitoring System) and the Forest Information Platform as data management function of the NFMS is sustainably implemented and utilized respectively. 2 50% of ASAL counties introduce the activities promoted by the Project. 3 National Forest Programme is updated.	・Citation in public documents ・Operation of NFMS ・Observation of activities			
Project Purpose Capacity at the national and county level for sustainable forest management is strengthened.	1 70% of direct beneficiaries recognize the improvement of policy implementation. 2 At least 3 entities (government, private, NGO/CBO) and individuals newly start growing of improved Melia volkensii in the ASALs. 3 REDD+ readiness process is advanced by the establishment of NFMS and FRL (Forest Reference Level). 4 KEFRI as AI-CD (African Initiative for Combatting Desertification) Regional Hub holds at least 5 Regional/National meetings, workshops and trainings for knowledge sharing. 5 Distribution system of seeds and seedlings of improved *Melia volkensii* is improved.	・Project reports ・Citation in public documents ・Interview	・There is no major changes of government institutional arrangement on forest and climate change policy.		
Outputs Output 1 (Policy Support) Implementing and monitoring capacities of forest-related policies/strategies at the national level are enhanced.	1-1 Monitoring and evaluation process of the National Forest Programme is established. 1-2 70% of stakeholders recognize the recommendation prepared by the Project as applicable and effective.	・Remarks and interview ・Project reports ・Interview	・Relevant policies currently under deliberation (National Forest Policy, Forest Conservation & Management Bill, National Climate Change Framework Policy, etc.) are finalized.		
Output 2 (Forestry Extension in ASALs through public, private and NGOs/CBOs partnership) Capacities of public and private sectors, and NGOs/CBOs to promote tree growing in ASALs are enhanced through forestry extension activities.	2-1 PFMP (Participatory Forest Management Plan), FFS (Farmer Field School) and other forestry extension approaches are applied in a strategic and coordinated manner in the Pilot Counties. 2-2 Collaboration among private and public sectors, and NGOs/CBOs is enhanced to promote tree growing in ASALs 2-3 More than 10 times of seminars/trainings for related stakeholders are held to promote improved Melia volkensii growing.	・Observation of activities at field based on the plan. ・Project reports ・Proposal/report submitted			
Output 3 (REDD+ Readiness) Technical capacities for REDD+ readiness activities and forest monitoring for sustainable forest management in KFS are strengthened.	3-1 The methodology of forest monitoring under the NFMS is established and documented. 3-2 Forest Information Platform as data management function of the NFMS is developed. 3-3 FRL is established in consultation with other stakeholders for submission to the UNFCCC by the Kenyan Government. 3-4 Creation of Land Cover/Land Use Map of 2020 is undertaken.	・Project reports ・Report to UNFCCC (United Nations Framework Convention on Climate Change)			
Output 4 (Tree Breeding) The capacity of breeding techniques for drought tolerant trees in KEFRI is improved.	4-1 Plus trees of *Melia volkensii* and *Acacia tortilis* are selected in the seed orchards and stands in Tiva and Kibwezi. 4-2 Researchers of KEFRI acquire the skills of artificial crossing technique.	・Project reports ・Visit/observation of the tree ・Interview of researchers ・Demonstration of the techniques			
Output 5 (Regional Cooperation) Capacity of regional cooperation in KEFRI is intensified by promoting knowledge sharing and transfer of technologies for strengthening the resilience to climate change and	5-1 Database on good practices to strengthen the resilience to climate change and drought in Sub-Saharan Africa is established to be referred by Kenya and other neighbouring countries. 5-2 70% of participating countries evaluate the regional cooperation useful.	・Access data of the website ・Records of the meetings. ・Project reports ・Interview of participating countries.			

drought in Sub-Sahara Africa.

Activities	Inputs		Important Assumption
	The Japanese Side	**The Kenyan Side**	
Output 1 (Policy Support) 1-1 Review existing/planned forest-related policies/strategies. 1-2 Conduct gap analysis between the existing forest-related policies/strategies and their actual implementation at field level. 1-3 Support planning and monitoring of National Forest Programme and other forest-related policies/laws. 1-4 Release policy briefs based on project activities. Output 2 (Forestry Extension in ASALs through public, private and NGOs/CBOs partnership) 2-1 Conduct a feasibility study and examine the approach for pilot implementation and select pilot Counties. 2-2 Assist formulation and implementation of PFMP in the pilot Counties 2-3 Support farmers to conduct FFS in strategic collaboration with implementation of PFMP in the Pilot Counties 2-4 Promote collaboration among government institutions, private entities and NGOs/CBOs in enhancing tree growing in ASALs 2-5 Promote tree growing of improved *Melia volkensii* in ASALs Output 3 (REDD+ Readiness) 3-1 Design, develop and test the NFMS for Kenya. 3-2 Operationalize the Forest Information Platform. 3-3 Conduct accuracy assessment of 2014 Land Cover/Land Use Map which is developed by SLEEK (System for Land-Based Emission Estimation in Kenya). 3-4 Create land cover/land use change maps using 4 historical data of land cover/land use maps. 3-5 Collect information on emission factors, set emission factors and develop 2014 Carbon 3-6 Analyse the land cover/land use changes based on the 4 time historical data of land cover/land use maps. 3-7 Develop and evaluate FRL with stakeholders. 3-8 Strengthen capacities for creating 2020 Land Cover/Land Use Map. 3-9 Train C/P for new technology or methodology of MRV (Measurement Reporting Verification) and test them for future development of MRV system in Kenya. Output 4 (Tree Breeding) 4-1 Improve the quality of clonal seed orchards of *Melia volkensii*. 4-2 Study of artificial crossing toward 2nd generation of *Melia volkensii*. 4-3 Improve the seedling seed stands of *Acacia tortilis*. Output 5 (Regional Cooperation) 5-1 Design the scope and prepare a TOR of regional cooperation by networking with related countries. 5-2 Hold regional cooperation meetings and forum. 5-3 Collect good practice information for strengthening the resilience to climate change and drought in Sub-Saharan Africa from Kenya and surrounding countries. 5-4 Accumulate the collected information, and establish the database on KEFRI's website. 5-5 Share the collected knowledge and technologies with other countries in Sub-Sahara Africa. 5-6 Improve access to finance to combat desertification.	1 Personal 【Long-term expert】 (1) Chief adviser/Forest policy (2) Regional cooperation/Coordinator (3) Forestry Extension 【Short-term expert (Consultant)】 (1) NFMS/FRL/MRV (Measurement, Reporting and Verification) (2) Tree breeding (3) Experts as necessary 2 Counterpart Training 3 Machinery, Equipment and Materials (1) Equipment for NFMS (2) Equipment for tree breeding extension (3) Equipment for information sharing (4) Vehicles (5) Other necessary machinery, equipment and 4 Supplementary budget for local expenditure	【Project management unit】 (1) Project Director - MENR (2) Director, KFS (3) Director, KEFRI 【OUTPUT Level】 (1) Project Manager - MENR (2) Component managers – MENR, (3) Counterpart/Administrative personnel 【Administrative staff】 (1) Secretary (2) Driver (3) Other staff 2 Land and Facilities (1) Project office in Nairobi (MENR, (2) Land and nursery for forest tree seed 3 Administrative and Operational Cost	・Ongoing relevant initiatives such as 1) formulation of national forest programme, 2) revision of Kenya NFMS Road Map, 3) upscaling of forest inventory to national level, are cooperative with the Project. ・Data from collaborating institutions including DRSRS and RCMRD (Regional Centre for Mapping of Resources for Development) are made available. ・Selection of pilot County governments is completed timely for efficient activity operation.
			Pre-Conditions ・Devolution of forest extension functions is agreed between KFS and county governments by March 2016 as stated by relevant acts.
			<Issues and countermeasures>

Appendix2 Flowchart of work



Appendix3 Plan of work operation

Appendix3-1 PO(2017.9-2021.6

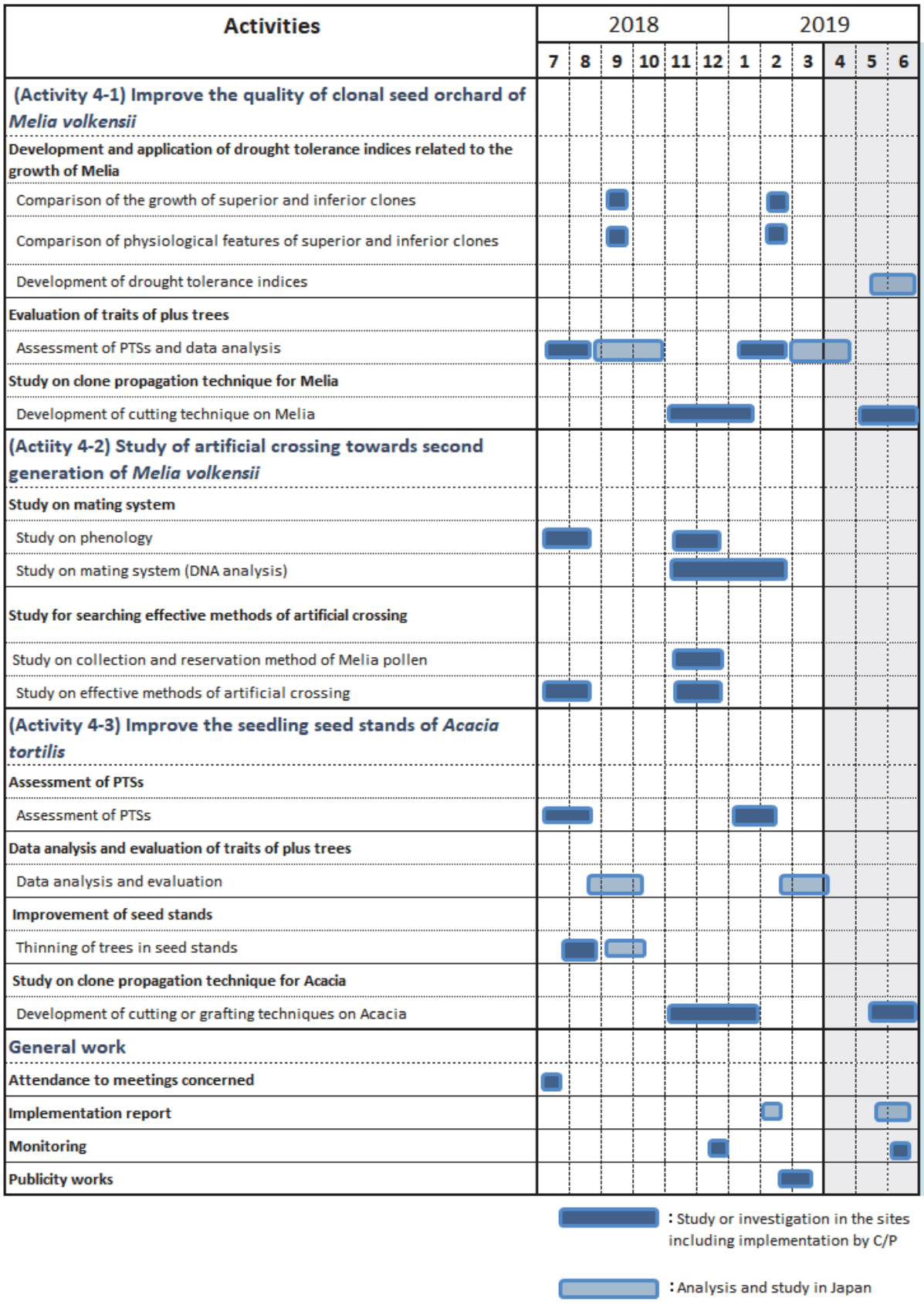
Activities	1st year				2nd year												3rd year												4th year											
	2017				2018												2019												2020											
	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
(Activity 4-1) Improve the quality of clonal seed orchard of *Melia volkensii*																																								
Development and application of drought tolerance indices related to the growth of Melia																																								
Comparison of the growth of superior and inferior clones																																								
Comparison of physiological features of superior and inferior clones																																								
Development of drought tolerance indices																																								
Classification of Candidate Plus tree into different drought tolerance levels																																								
Evaluation of traits of plus trees																																								
Assessment of PTSs and data analysis																																								
Development of Plus trees traits table																																								
Guidance on maintenance measures of PTSs																																								
Improvement of the existing seed orchards																																								
Stem cutting and branch pruning																																								
Rogueing of inferior trees																																								
Development of a manual for maintenance of seed orchard																																								
Development of manual																																								
Technical support																																								
Study on clone propagation technique for Melia																																								
Development of cutting technique on Melia																																								
(Actiity 4-2) Study of artificial crossing towards second generation of *Melia volkensii*																																								
Study on mating system																																								
Study on phenology																																								
Study on mating system (DNA analysis)																																								
Study for searching effective methods of artificial crossing																																								
Study on collection and reservation method of Melia pollen																																								
Study on effective methods of artificial crossing																																								
(Activity 4-3) Improve the seedling seed stands of *Acacia tortilis*																																								
Assessment of PTSs																																								
Assessment of PTSs																																								
Data analysis and evaluation of traits of plus trees																																								
Data analysis and evaluation																																								
Improvement of seed stands																																								
Thinning of trees in seed stands																																								
Study on clone propagation technique for Acacia																																								
Development of cutting or grafting techniques on Acacia																																								
General work																																								
Attendance to meetings concerned																																								
Implementation report																																								
Monitoring																																								
Publicity works																																								

: Study or investigation in the sites including implementation by C/P

: Analysis and study in Japan

Appendix3 Plan of work operation

Appendix3-2 PO(2018.7－2019.6)



Appendix3 Plan of work operation

Appendix3-3 PO(2019.4－2020.3)

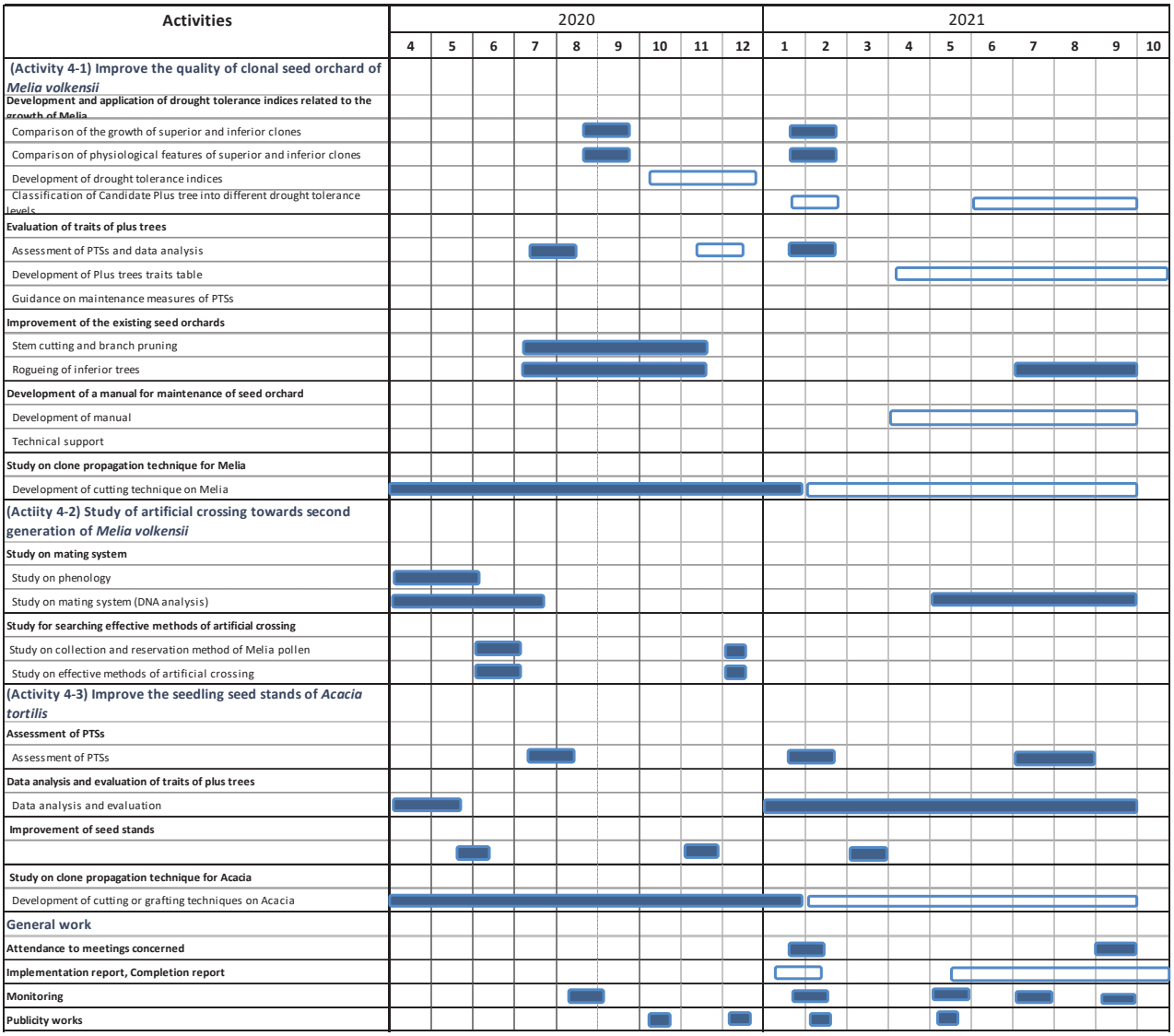
Activities	2019									2020		
	4	5	6	7	8	9	10	11	12	1	2	3
(Activity 4-1) Improve the quality of clonal seed orchard of *Melia volkensii*												
Development and application of drought tolerance indices related to the growth of Melia												
Comparison of the growth of superior and inferior clones					■						■	
Comparison of physiological features of superior and inferior clones					■							
Development of drought tolerance indices							▭	▭	▭			
Evaluation of traits of plus trees												
Assessment of PTSs and data analysis	▭	▭	▭					▭	▭		■	■
Study on clone propagation technique for Melia												
Development of cutting technique on Melia		■	■	■				■	■			
(Actiity 4-2) Study of artificial crossing towards second generation of *Melia volkensii*												
Study on mating system												
Study on phenology	■	■	■									
Study on mating system (DNA analysis)	■	■	■	■	■							
Study for searching effective methods of artificial crossing												
Study on collection and reservation method of Melia pollen			■	■					■			
Study on effective methods of artificial crossing			■	■					■			
(Activity 4-3) Improve the seedling seed stands of *Acacia tortilis*												
Assessment of PTSs												
Assessment of PTSs				■	■							■
Data analysis and evaluation of traits of plus trees												
Data analysis and evaluation	▭	▭	▭					▭	▭	▭	▭	▭
Improvement of seed stands												
Thinning of trees in seed stands					■							
Study on clone propagation technique for Acacia												
Development of cutting or grafting techniques on Acacia								■				
General work												
Attendance to meetings concerned		■		■								
Implementation report										▭	▭	
Monitoring					■						■	
Publicity works							■		■		■	

■ : Study or investigation in the sites including implementation by C/P

▭ : Analysis and study in Japan

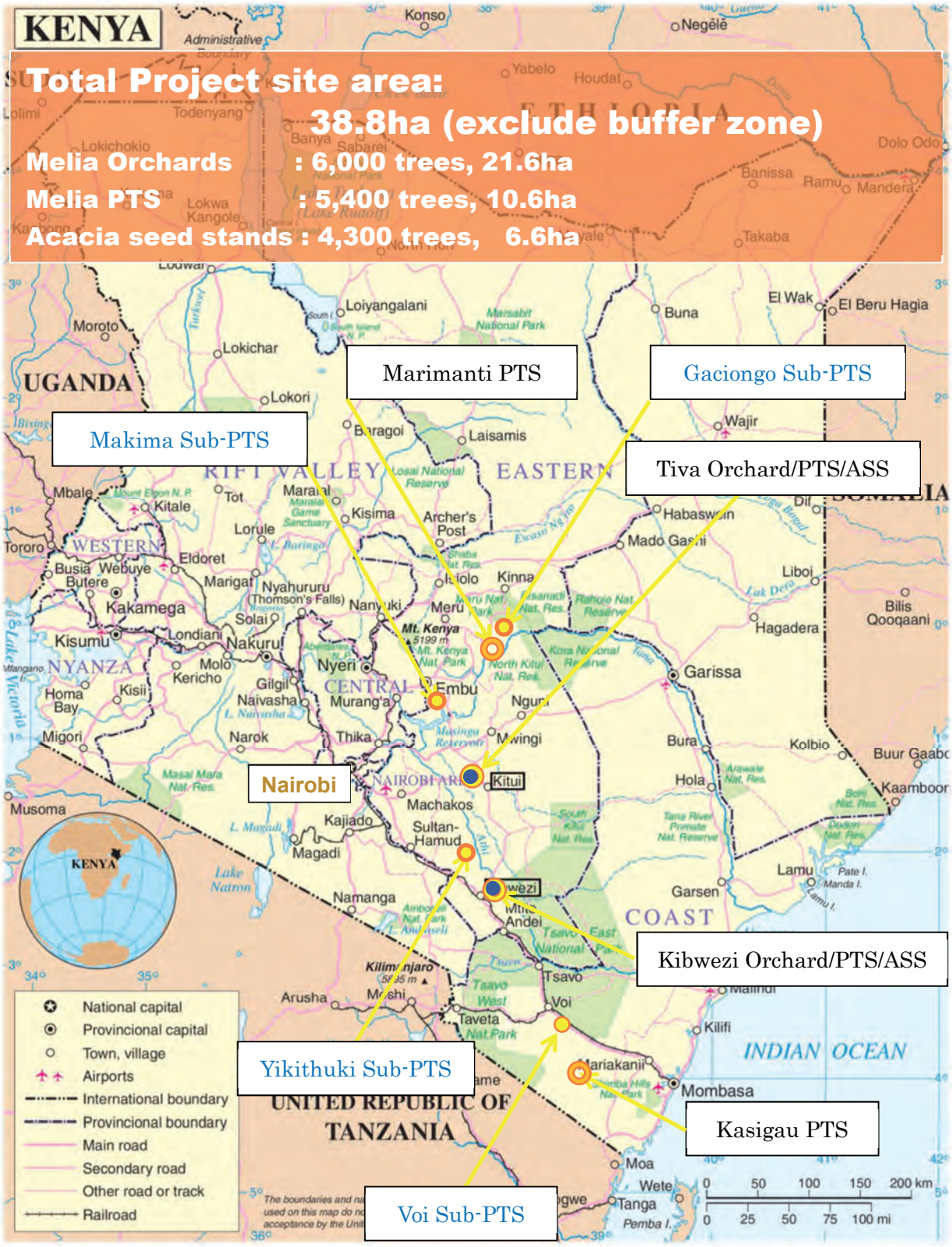
Appendix3 Plan of work operation

Appendix3-4 PO(2020.4－2021.10)



Appendix 4: Location of the Orchards/Stands and PTS

Melia Orchards/Progeny Test Sites & Acacia Seed Stands Location Map



Melia Orchard/PTS/Acacia Seed Stand PTS Sub-PTS

Number of plantation and area in the Project

Clonal Seed Orchard of *Melia volkensii*

Numberof plantation

	2012	2013	2014	2015	2016	Total
Tiva orchard	1,800	600	600			3,000
Kibwezi orchard	1,800	600	600			3,000
Total	3,600	1,200	1,200			6,000

Area (ha)

	Area of plantation	Area of boundary*
Tiva orchard	10.8	12.4
Kibwazi orchard	10.8	12.8
Total	21.6	25.2

Progeny Test Site of *Melia volkensii*

Numberof plantation

	2012	2013	2014	2015	2016	Total
Gaciongo subPTS				160		160
Marimanti PTS			160	864		1,024
Makima subPTS				160		160
Tiva PTS			480	864		1,344
Yikithuki subPTS				160		160
Kibwezi PTS			480	864		1,344
Voi subPTS				160		160
Kasigau PTS			180	864		1,044
Total			1,300	4,096		5,396

Area (ha)

	Area of plantation	Area of boundary*
Gaciongo subPTS	0.3	0.4
Marimanti PTS	2.0	2.9
Makima subPTS	0.3	0.4
Tiva PTS	2.5	4.8
Yikithuki subPTS	0.3	0.4
Kibwezi PTS	2.9	3.8
Voi subPTS	0.3	0.4
Kasigau PTS	2.0	4.0
Total	10.6	17.1

Seedling Seed Stand of *Acacia tortilis*

Number of plantation

	2012	2013	2014	2015	2016	Total
Tiva seed stand				500	1,200	1,700
Kibwezi seed stand				648	1,944	2,592
Total				1,148	3,144	4,292

Area (ha)

	Area of plantation	Area of boundary*
Tiva seed stand	2.8 including no planting area, 0.7	6.1
Kibwazi seed stand	3.8	5.0
Total	6.6	11.1

* Area of boundary : Area of plantation + buffer zone

Appendix 4 - *Melia volkensii* CPT Transects(selection areas)

Region	S/No.	Transect Name	No. of CPTs	*Code*
Coastal	1	Voi - Mwatate	10	VM
	2	Voi-Galana	10	VG
South Eastern	3	Mutha - Inyali	12	MTA
Central Eastern	4	Katulani - Kavisuni	10	KT
Central	5	Mwea Special	2	MWA
Eastern	6	Mwingi - Tseikuru	8	TSK
	7	Mwingi - Nuu	4	NUU
	8	Embu - Dams	7	EmbD
	9	Embu-Ishiara-Gatunga	13	EmbIG
Northern	10	Meru - Isiolo	4	MI
	11	Garissa-Bangale	4	GB
	12	Garba-Wamba	6	GW
	13	Wamba-Marsabit	10	WM
		TOTAL	**100**	

Table 1: Transects across Melia areas of occurrence and number of CPTs selected

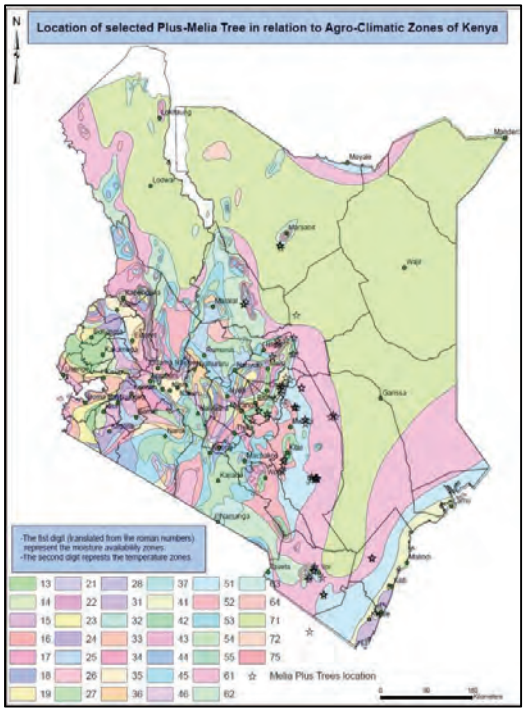


Figure 2: Melia Candidate plus Trees location sites in relation to Agro-climatic zones

Appendix 4- *Acacia tortilis* CPT Transects (selection areas)

Block	T/No.	Transect Name	No of CPTs
A	1 &2	Tana-Lamu	11
B	3	Voi-Mwatate	6
	4&5	Machakos-Mwingi	11
C	6	Isiolo-Garba	4
	7	Archers-Isiolo	4
D	8	Maralal-Wamba	8
	9 & 10	Wamba-Marsabit	8
H/A	11&12	Garissa	6
E	13	Loitokitok-Namanga	9
	14	Kajiado-Magadi	4
	15	Namanga-Kajiado	8
C	Added	Tharaka	4
F	16	Baringo	6
G	17, 18 &19	Turkana	7
B	20	Kibwezi	4
		TOTAL	**100**

Table: Transects from which *Acacia tortilis* CPTs were selected

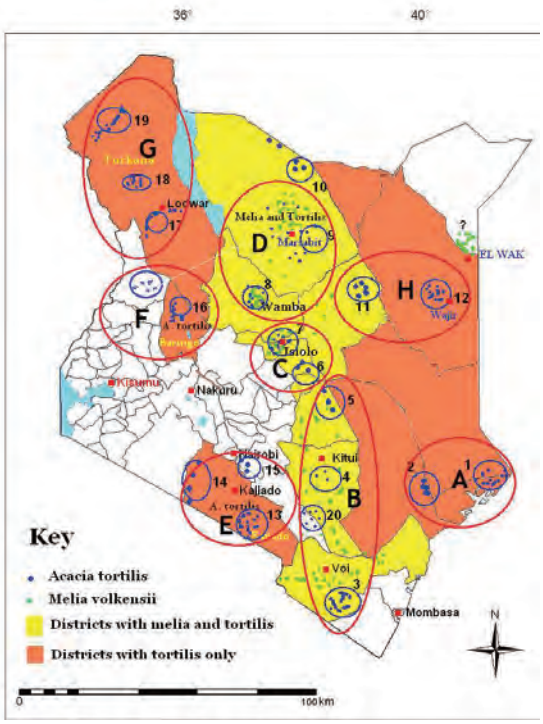


Figure: Distribution of Acacia tortilis blocks and populations for selection of CPTs (Table)

Layout of Tiva Melia clonal seed orchard

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
50	62	33	77	80	11	4	69	31	67	97	56	70	41	50	15	69	10	78	2	97	73	83	23	51	54	42	49	44	59	5	97	7	6	68	51	25	64	20	31	11	84	63	42	25	10	66	75	79	15	47	60	41	8	13	7	80	82	65	94	27
49	90	78	10	63	73	65	33	21	40	25	80	24	58	90	38	36	86	53	37	35	65	79	99	55	50	65	17	22	67	81	61	98	85	95	48	1	50	27	39	89	18	59	87	68	49	74	81	14	44	88	45	61	91	72	52	62	18	15	83	86
48	71	85	38	25	48	20	100	78	88	8	91	14	19	94	55	31	44	66	11	94	31	9	29	26	100	19	52	18	93	88	4	77	14	67	3	71	66	86	82	10	95	45	85	24	28	22	91	96	36	25	48	57	39	30	2	14	53	97	16	22
47	37	14	58	98	38	22	89	74	5	32	23	82	99	7	1	95	26	88	33	5	53	60	78	32	77	80	36	85	23	92	64	58	60	76	89	24	99	47	93	60	71	2	64	26	38	70	13	63	18	1	84	19	96	32	79	55	89	81	8	46
46	72	66	28	2	60	82	17	41	84	49	60	22	87	18	21	46	76	57	52	20	46	43	44	1	82	39	13	79	28	38	51	26	18	70	40	65	62	44	74	67	7	55	62	99	5	54	56	90	37	26	87	95	25	71	92	9	99	47	20	32
45	70	68	81	15	29	47	90	28	93	36	77	52	96	35	48	93	24	59	42	30	24	81	40	21	15	25	87	5	56	32	20	34	91	13	57	83	33	84	43	100	6	97	75	50	12	10	39	29	93	67	23	66	38	74	4	70	98	10	27	23
44	75	9	95	96	10	79	69	12	98	3	51	9	83	72	71	36	32	74	83	71	73	70	92	9	16	94	6	74	49	37	24	31	47	54	92	50	56	11	1	22	46	69	68	80	47	77	34	89	53	35	75	20	11	52	13	33	68	42	43	86
43	19	56	77	45	16	64	18	43	33	85	75	63	13	45	5	53	40	34	54	23	14	27	51	63	89	30	46	72	29	69	93	7	63	45	53	8	27	72	36	91	51	88	66	60	19	15	33	52	99	4	59	76	90	100	3	93	94	76	24	64
42	35	51	32	48	88	61	6	73	70	11	7	39	6	91	97	16	6	7	66	62	67	95	50	37	12	11	35	71	45	12	77	61	80	99	69	12	4	10	63	98	10	14	70	2	83	38	96	41	3	22	46	36	83	57	97	16	85	39	77	53
41	78	59	74	20	24	57	63	46	82	71	81	60	90	19	80	12	89	87	44	72	90	8	29	34	28	48	59	73	66	55	88	28	59	39	25	30	73	61	39	90	55	35	30	5	100	72	54	69	1	92	21	63	48	9	73	46	72	67	78	40
40	100	87	85	42	65	68	15	22	80	99	65	61	62	24	29	27	56	23	18	93	80	53	4	41	96	23	8	65	20	4	94	2	38	75	15	79	88	42	38	52	54	64	43	31	4	57	78	97	10	65	94	32	7	60	80	59	36	58	1	56
39	99	12	26	89	97	67	59	83	92	14	74	78	76	8	43	73	10	84	47	98	78	2	92	84	21	58	52	26	67	21	78	19	32	68	100	16	40	59	86	68	85	84	82	86	23	6	28	58	29	18	56	62	98	15	43	19	65	5	17	51
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37	22	8	53	95	55	75	35	30	25	3	27	37	64	31	33	23	32	94	17	37	3	45	33	75	36	69	47	77	95	84	22	46	80	99	48	82	84	29	5	47	34	95	94	14	16	89	2	70	83	93	100	28	97	11	26	35	93	38	42	4
36	34	47	39	46	81	41	96	88	53	44	47	46	89	80	4	30	100	87	83	25	62	15	57	17	35	97	9	91	76	45	53	83	16	57	63	55	9	76	93	81	32	71	48	24	45	69	47	12	79	75	1	31	73	20	48	100	89	76	14	72
35	57	31	45	58	63	79	19	85	4	89	32	6	35	85	15	50	41	42	40	88	72	41	76	95	70	39	19	86	11	12	70	98	44	33	28	26	90	43	22	66	87	49	56	38	75	73	81	13	40	76	53	82	87	52	49	12	36	79	28	61
34	40	29	36	13	91	38	71	70	82	49	21	43	54	19	18	4	52	49	43	58	4	13	78	5	56	16	20	48	13	55	3	62	8	72	50	20	36	79	21	10	92	6	96	79	58	80	86	37	78	3	8	61	43	9	50	60	62	17	21	34
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27	21	57?	54	56	95	92	55	17	5	58	77	16	34	56	96	48	79	18	2	86	94	85	97	2	6	49	56	99	89	33	87	85	98	83	7	49?	75	18	27	14	25	48	95	61	52	73	53	54	26	9	17	50	86	98	49	67	11	44	26	31
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20	28	34	25	43	15	63	12	39	99	58	6	24	1	98	19	59	61	58	83	62	60	59	35	77	72	41	40	29	3	54	34	4	25	63	38	66	13	86	58	82	97	45	4	31	49	24	16	85	11	48	61	71	81	35	11	27	4	41	84	21
19	51	10	6	97	62	50	72	74	81	90	49	32	83	78	26	60	3	80	52	18	9	22	49	56	45	65	22	59	44	91	58	2	51	82	50	74	40	43	61	51	95	27	55	39	77	15	76	42	45	34	39	74	60	85	1	65	19	39	100	57
18	58	41	11	81	8	22	93	55	42	77	48	43	100	20	77	54	72	8	21	42	48	66	79	25	27	73	10	70	18	85	94	19	73	46	80	20	99	69	42	98	3	7	8	61	43	82	94	97	80	58	83	31	10	40	72	89	38	81	77	62
17	36	37	65	13	95	53	59	38	64	66	76	96	46	37	71	34	74	70	32	29	63	46	26	90	82	60	69	87	16	32	48	69	28	8	71	32	94	12	96	68	23	85	86	91	87	23	12	2	25	32	6	15	54	67	56	45	12	34	36	25
16	12	74	32	27	47	20	85	56	67	89	50	5	70	45	13	68	49	5	81	57	95	98	53	76	83	19	78	36	33	8	11	92	55	44	75	26	88	17	54	63	47	28	2	78	26	65	7	8	68	100	41	52	87	79	33	96	7	88	24	79
15	100	59	48	54	79	25	35	29	44	95	14	40	4	53	9	2	14	55	67	75	13	34	40	15	38	94	39	74	54	29	83	56	10	14	97	91	18	39	5	60	80	45	6	51	17	52	33	22	92	66	89	51	18	80	9	4	99	75	2	13
14	94	49	16	67	80	94	90	84	3	39	27	21	86	59	79	22	52	58	56	89	85	62	49	88	93	55	77	53	72	21	1	93	43	6	34	52	35	24	21	1	48	100	10	96	75	49	79	40	36	30	39	57	88	63	8	66	55	57	91	94
13	7	60	41	93	4	50	30	63	100	33	57	83	62	78	73	41	50	82	1	24	99	71	18	52	24	81	47	97	89	49	85	80	5	50	67	46	89	15	14	81	84	99	36	66	76	58	3	69	46	10	59	3	85	53	5	90	15	19	25	84
12	15	39	11	43	70	86	43	30	72	82	42	77	88	10	87	98	51	66	21	47	60	70	31	73	2	66	70	42	82	38	45	96	69	25	62	86	57	72	56	43	71	98	42	46	30	93	35	53	37	74	11	34	69	35	49	25	60	58	59	64
11	35	92	23	23	89	2	18	75	7	24	99	48	84	61	31	11	94	86	88	25	64	83	100	21	95	99	35	37	76	7	90	77	58	78	99	47	65	13	4	85	50	23	87	92	21	97	20	4	24	98	26	20	19	73	86	92	56	20	100	16
10	20	69	84	57	85	34	35	53	36	44	23	70	56	81	92	2	36	54	91	9	74	4	45	16	32	22	62	68	79	92	22	16	97	10	39	76	91	54	19	41	27	69	65	78	7	9	51	16	82	5	38	6	91	96	41	11	47	71	53	93
9	51	18	52	13	73	6	5	21	45	43	21	97	29	65	74	45	30	95	28	39	90	50	75	67	92	5	53	31	10	75	15	56	8	28	34	36	87	58	66	28	75	29	62	60	10	64	50	42	61	76	77	47	54	42	51	63	40	14	13	42
8	44	4	14	73	96	97	33	37	95	68	22	63	80	38	96	49	8	69	99	10	37	20	7	3	15	87	63	50	61	30	74	1	67	32	100	12	14	30	40	59	31	27	73	74	84	22	86	52	66	83	9	72	46	34	43	65	99	24	68	21
7	55	62	93	64	66	1	55	56	83	78	86	79	53	28	98	71	87	42	65	98	57	80	6	9	77	27	43	7	11	4	24	27	73	55	44	89	64	42	7	2	8	14	54	83	45	67	17	73	29	14	11	71	31	44	59	38	6	1	28	15
6	91	33	9	83	24	87	15	40	69	8	100	46	32	1	82	88	15	7	34	1	70	84	88	79	26	51	42	66	81	84	95	41	3	33	88	26	29	45	95	39	37	52	88	33	44	56	92	13	94	30	21	98	53	97	79	92	50	27	64	46
5	77	72	12	54	50	46	71	48	61	36	99	77	84	40	3	75	41	26	94	17	71	72	46	65	57	29	62	22	78	98	17	21	5	79	71	37	20	19	33	94	82	80	91	3	32	35	5	49	43	63	48	70	1	17	25	60	20	12	96	72
4	63	82	47	8	58	38	82	4	43	59	45	66	23	10	29	52	36	62	48	5	74	17	97	35	47	59	41	2	52	58	20	75	6	80	85	82	50	98	23	49	48	69	72	64	76	59	77	81	10	90	18	75	35	94	39	3	78	75	82	67
3	26	23	30	51	96	35	88	29	60	65	85	93	19	27	57	64	91	20	22	28	99	96	68	83	91	12	38	25	28	36	48	94	91	10	25	86	21	9	100	93	55	62	41	34	21	36	86	57	95	32	50	67	28	65	22	32	81	61	37	5
2	2	60	76	63	92	13	32	19	67	81	11	68	90	97	16	18	76	2	33	95	12	49	89	55	93	69	9	46	8	70	77	65	38	7	61	18	12	17	30	43	68	24	66	90	58	1	47	28	89	88	62	29	84	43	69	93	70	29	16	44
1	17	65	85	7	79	69	37	17	74	92	54	24	98	73	38	60	9	61	6	4	30	64	75	86	23	67	76	31	18	1	92	11	53	87	3	44	34	90	60	16	54	4	2	70	63	30	54	98	73	93	12	74	13	95	71	90	56	19	23	22
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60

Site layout and planting

・100 families × 30 trees =3,000 trees (2012year 60 families × 30 trees = 1,800 trees、2013year 20 families × 30 trees = 600 rees、2014 year 20 families × 30 trees = 600trees)

・6 blocks (1 block 25trees × 20 trees = 500 trees 、Spacing 6m×6m)

Layout of Kibwezi Melia clonal seed orchard

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
50		32	82	63	2	70	39	20	98	96	66	93	36	63	65	74	8	38	70	17	88	35	56	48	73	31	92	33	74	75	84	64	37	41	46	96	28	100	35	54	5	95	40	74	29	49	84	60	98	9	25	92	7	75	53	25	38	88	74	83	7	73
49		61	54	7	97	8	45	31	89	34	81	87	14	97	3	75	22	91	16	87	13	66	54	16	46	11	30	70	21	4	77	46	26	95	4	65	77	38	50	53	70	72	7	47	46	28	12	95	26	3	88	36	56	1	14	50	80	81	71	5	94	40
48		85	4	92	17	67	15	74	86	46	94	19	68	21	60	52	69	1	89	10	5	22	80	28	61	19	45	52	18	1	15	87	73	67	53	57	42	89	60	29	81	63	17	19	22	6	63	59	94	55	35	15	68	13	53	90	35	19	96	28	50	76
47		79	77	98	14	75	83	41	21	71	56	26	44	17	8	42	96	71	4	67	63	21	3	2	57	26	65	88	40	2	80	90	30	10	16	92	24	71	14	17	44	39	62	85	36	65	50	68	74	58	5	54	89	70	44	73	86	23	69	46	4	9
46		91	30	43	36	26	100	35	62	78	84	50	45	35	86	81	20	93	47	77	11	7	55	82	59	15	5	54	98	39	86	79	71	50	74	32	58	48	13	12	30	45	4	57	87	79	82	30	21	100	2	45	39	64	51	53	49	68	30	89	61	97
45		44	68	19	76	18	55	51	63	30	58	12	49	95	32	27	78	92						58	95	24	20	100	84	57	12	14	37	13	11	97	49	83	94	40	97	67	95	90	23	98	84	73	67	71	17	80	49	20	8	100	3	79	83	93	72	32
44		28	33	34	64	90	65	7	72	11	87	73	82	72	64	97	38	11						14	34	49	71	41	63	31	33	59	89	88	54	85	72	46	21	55	69	78	38	52	1	91	37	2	22	88	31	97	24	77	43	91	6	27	71	14	56	78
43		69	78	21	88	13	86	31	85	1	54	36	40	68	43	57	90	24						61	31	86	16	47	76	3	27	45	41	35	65	95	59	29	41	73	9	42	93	64	99	9	66	45	16	87	18	41	94	61	32	21	95	1	76	28	13	41
42		60	75	40	79	95	2	93	75	24	37	99	50	62	17	61	5	29						66	83	8	18	10	99	81	6	67	7	100	69	47	76	19	39	35	86	3	8	12	57	13	74	8	68	75	15	47	62	98	23	60	14	51	39	1	99	100
41		20	39	11	49	3	45	48	6	25	59	22	94	47	66	14	16	33						22	80	97	77	25	91	62	32	26	77	12	68	6	99	48	74	52	66	56	10	22	43	29	36	6	96	52	3	92	30	25	11	67	52	29	69	10	3	16
40		15	52	44	84	61	67	76	71	28	25	79	80	6	41	59	95	28	2	32	3	16	20	94	89	52	1	84	36	64	75	38	1	39	61	25	56	36	98	34	16	100	60	23	2	79	24	27	25	64	93	33	48	19	46	16	47	7	83	57	87	17
39		12	54	77	57	55	10	33	77	82	98	50	9	89	58	4	23	37	44	92	60	42	62	29	90	93	7	11	13	85	87	40	84	43	62	55	81	78	22	75	24	59	30	44	61	33	91	71	98	50	51	5	99	63	70	88	24	42	26	33	92	65
38		67	6	86	24	89	23	63	96	56	100	51	46	19	57	64	21	80	6	15	48	5	10	64	96	56	68	54	53	24	94	44	58	37	83	10	42	27	13	93	58	88	85	72	45	95	73	26	31	87	44	65	69	42	41	90	48	45	34	56	82	90
37		79	73	74	26	31	66	59	90	29	20	15	36	72	90	49	78	81	47	7	69	46	6	92	76	12	37	55	50	99	27	69	60	65	73	51	23	45	44	80	47	94	57	63	34	9	67	49	48	20	32	23	80	84	55	59	38	8	20	43	70	2
36		25	47	22	42	93	4	9	65	34	35	7	13	96	76	27	94	85	14	56	74	55	78	80	34	82	95	8	25	98	35	2	17	29	71	99	67	91	43	92	9	90	55	70	96	83	3	37	81	10	76	28	2	83	27	94	22	60	74	79	75	16
35		16	9	58	53	60	25	13	70	95	84	28	61	41	48	73	10	33	34	8	76	31	49	19	33	36	51	23	78	47	48	96	7	20	76	46	26	32	6	57	79	29	4	77	43	27	50	59	53	47	82	21	100	58	29	11	30	80	58	15	41	62
34		27	53	88	99	38	37	75	51	31	18	2	83	91	45	40	92	12	43	50	48	52	22	44	90	1	52	15	9	13	89	97	5	72	61	49	18	70	64	28	87	23	53	5	33	91	75	93	39	72	33	78	12	81	66	18	93	98	22	72	78	84
33		52	64	12	5	23	62	40	98	64	71	85	1	25	65	100	79	83	11	18	39	51	26	60	63	100	91	85	32	59	38	86	82	31	25	30	58	21	10	17	81	2	86	35	89	82	54	95	62	9	63	25	67	91	51	47	37	54	99	17	11	18
32		55	30	80	41	73	7	30	86	27	100	81	53	38	89	72	24	3	71	60	81	91	6	79	11	2	43	21	20	53	60	43	15	19	74	11	89	60	22	39	49	42	12	42	64	66	26	99	36	46	42	44	36	34	40	90	1	48	32	65	59	35
31		17	69	22	36	56	91	57	42	45	56	12	35	96	58	19	23	1	82	57	62	80	69	87	92	34	37	62	8	36	75	1	98	93	36	68	63	3	82	85	93	55	62	48	76	31	15	10	79	1	85	97	55	24	52	39	77	97	86	12	51	66
30		61	67	92	66	20	74	29	70	9	13	43	95	80	3	88	69	26	78	5	85	24	72	88	57	14	71	47	51	96	79	33	56	40	27	75	79	4	41	8	66	42	94	59	8	61	81	19	24	84	20	86	56	100	82	68	28	61	70	8	34	37
29		49	83	38	35	18	21	53	88	66	94	47	22	46	29	90	93	94	99	54	50	23	51	27	33	12	5	15	24	45	64	91	52	5	28	84	76	50	65	34	16	98	43	13	4	32	38	27	14	5	77	87	6	88	69	45	20	55	80	49	21	41
28		46	68	6	2	97	14	40	68	65	87	34	33	51	48	16	9	49	39	76	41	55	38	68	4	25	48	82	73	18	32	97	23	51	62	17	67	70	40	91	28	30	58	92	34	75	37	29	18	78	54	66	64	31	17	85	14	6	92	54	38	39
27		43	84	100	4	15	10	1	37	30	82	97	59	62	70	77	37	18	42	44	8	59	3	66	9	63	44	50	68	69	87	99	88	14	38	72	18	81	86	90	96	53	19	42	77	57	16	14	44	71	89	63	46	21	58	18	56	76	7	78	96	89
26		10	28	32	39	54	99	52	32	19	26	53	58	99	83	84	73	27	72	29	87	98	93	61	83	94	31	23	8	19	83	70	78	17	7	85	74	20	9	77	43	4	69	60	31	35	65	40	52	72	11	26	40	67	13	96	73	97	86	4	85	10
25	13	3	81	92	36	57	3	9	25	74	4	55	31	40	60	15	57	92								7	47	53	90	42	89	20	39	71	41	24	21	13	71	59	29	46	88	47	8	89	30	49	45	76	42	100	29	3	39	32	25	83	60	15	13	36
24	16	61	88	78	79	56	38	77	6	7	11	29	8	76	33	56	21	3								45	43	36	59	84	5	98	58	29	57	34	4	8	63	80	66	84	20	85	61	97	83	99	43	27	88	16	22	2	47	36	74	34	16	42	33	18
23	9	52	25	8	73	60	85	64	96	45	24	17	9	5	79	20	36	61								75	77	1	100	27	79	52	55	16	46	28	32	35	23	12	3	14	74	1	9	3	50	98	80	82	61	87	60	62	91	77	26	35	46	11	65	23
22	56	18	55	100	68	66	94	76	92	62	16	88	48	98	45	74	64	85								72	92	15	40	60	22	75	14	12	26	37	2	19	31	87	82	27	81	54	52	34	4	39	55	68	52	56	97	19	89	41	11	82	31	21	38	78
21	86	37	50	4	7	70	47	28	12	52	33	38	32	49	86	1	10	82								25	96	82	23	85	87	74	65	40	86	95	75	100	94	15	68	76	78	62	38	60	95	40	77	11	70	5	48	41	49	61	84	17	55	96	92	33
20	67	2	84	51	15	80	82	50	30	14	90	94	89	34	15	75	6	42								74	5	79	10	54	38	93	43	83	44	50	62	79	24	11	47	91	67	43	45	14	86	36	51	1	44	23	9	10	43	92	64	60	2	24	76	51
19	1	61	93	95	17	99	27	65	91	35	69	47	29	67	76	22	41	23								68	70	42	3	26	95	61	41	21	81	58	78	72	45	64	96	31	100	19	23	87	6	92	2	99	75	37	76	32	63	47	7	90	79	48	94	3
18	71	47	73	78	57	36	23	54	77	87	55	18	36	57	39	59	65	71	100	97		28	91	54	36	22	84	49	97	60	47	35	17	99	73	53	28	61	5	6	8	26	88	10	65	28	90	58	12	98	69	100	36	67	50	94	27	4	91	66	74	50
17	83	28	66	97	35	11	5	42	62	46	58	92	26	53	50	27	90	43	48	85	50	1	26	73	34	41	18	83	29	81	27	30	6	94	9	59	98	89	33	69	55	56	12	17	41	53	21	93	13	28	8	17	83	13	31	75	14	39	13	63	6	20
16	69	14	13	34	63	20	6	43	93	25	75	99	85	20	52	93	48	44	24	37	45	21	53	30	56	35	25	21	8	39	66	46	77	67	56	84	10	20	48	16	18	76	15	7	30	62	82	59	20	45	22	73	97	72	45	34	56	58	68	85	41	72
15	53	43	2	72	51	74	88	71	48	3	61	82	2	1	91	10	75	89	35	68	60	77	42	65	37	62	48	99	10	57	76	31	54	12	93	49	14	63	86	29	2	92	66	31	64	25	27	95	55	44	89	21	26	35	12	64	73	86	49	99	32	18
14	9	7	38	84	25	40	7	29	27	70	8	24	21	37	69	41	72	81	6	82	45	72	63	11	40	66	64	2	54	88	50	11	74	44	82	97	80	13	32	94	87	93	95	73	56	57	5	87	61	76	25	70	77	55	65	24	95	33	37	35	67	9
13	59	75	46	8	70	32	94	54	15	100	57	97	23	78	100	22	63	34	54	46	20	76	91	89	4	69	36	93	60	9	16	41	15	5	43	7	6	70	75	77	78	17	40	8	86	80	39	63	68	18	47	39	52	92	51	84	94	14	46	81	93	98
12	40	2	4	26	47	1	89	98	31	87	55	72	74	19	80	87	76	55	95	47	70	1	28	51	95	50	31	52	33	70	32	81	65	1	62	19	36	34	57	85	7	50	67	34	75	81	91	28	84	51	71	93	46	27	1	71	10	54	100	59	91	28
11	96	49	62	44	82	79	28	46	91	63	33	5	66	60	73	99	18	3	96	67	8	85	74	6	39	35	79	12	75	55	18	37	78	7	22	11	2	26	69	83	38	61	71	44	16	33	60	88	24	59	54	49	14	5	69	98	74	96	80	8	70	4
10	60	65	77	83	81	20	19	93	52	26	51	12	89	85	79	83	12	59	84	98	75	83	97	86	49	65	45	78	24	100	29	98	8	48	90	30	86	48	32	64	79	88	10	74	100	72	79	96	53	37	94	29	32	78	68	29	63	40	25	62	64	6
9	22	19	21	12	33	80	97	34	84	7	11	44	30	14	52	17	42	62	91	19	66	80	68	96	67	11	14	90	92	40	91	56	87	92	49	10	88	99	47	16	92	27	21	66	65	1	15	43	5	22	57	58	48	50	35	83	16	34	58	53	99	43
8	51	95	99	13	86	39	41	50	73	21	22	68	23	71	24	37	29	32	58	90	39	46	20	18	30	69	44	34	72	58	25	82	17	95	3	97	12	51	4	3	68	15	86	19	62	95	17	20	69	70	55	72	61	38	81	4	26	79	84	3	36	90
7	42	39	17	11	18	98	54	10	69	29	99	56	34	98	61	72	10	38	49	16	63	72	81	5	54	57	43	63	73	16	62	20	1	61	23	53	85	14	17	94	96	13	73	26	83	25	31	87	85	8	28	15	66	71	21	54	93	2	56	41	77	22
6	56	64	58	35	9	28	27	25	60	42	10	88	6	5	27	32	67	73	14	86	13	9	89	88	99	98	71	64	85	86	23	77	66	41	68	42	19	24	89	52	57	61	18	97	48	42	99	7	75	6	11	35	79	46	44	59	7	45	75	37	27	12
5	40	26	24	90	68	45	100	67	64	26	33	41	15	41	89	94	83	4	12	53	1	59	48	23	78	52	51	21	2	83	80	22	33	51	40	63	37	18	95	59	100	93	84	30	53	29	72	90	38	52	40	89	2	32	77	48	91	57	19	82	69	64
4	39	94	2	46	88	96	80	72	30	78	17	58	63	79	36	69	22	65	80	54	64	73	19	24	3	38	36	65	25	27	96	39	9	9	88	67	31	60	71	33	67	56	37	66	81	49	93	10	14	24	26	82	57	16	98	40	96	17	13	46	78	9
3	44	37	5	30	87	14	40	16	76	83	49	71	87	53	43	45	92	96	95	28	58	94	51	69	45	42	7	32	76	6	37	44	87	4	15	80	43	28	10	39	38	55	5	24	71	59	54	86	94	22	69	18	20	50	51	31	38	30	70	80	42	44
2	84	70	49	21	18	74	95	31	91	68	90	65	19	16	78	30	66	81	51	13	43	66	33	49	58	22	47	82	100	52	53	13	64	62	79	17	25	74	35	91	90	44	87	1	52	85	68	19	97	96	56	30	67	47	63	78	89	85	65	6	88	7
1	31	38	23	81	97	77	31	4	48	50	86	59	77	11	93	44	62	53	59	32	35	8	67	81	4	46	55	71	20	34	70	30	84	38	90	58	19	99	13	98	97	70	15	92	12	23	57	79	53	80	29	42	76	3	73	9	11	58	23	90	4	33
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62

Site layout and planting

・100 families × 30 trees =3,000 trees (2012year　60 families × 30 trees = 1,800 trees、2013year 20 families × 30 trees = 600 rees、2014　year　20 families × 30 trees = 600trees)

・6 blocks (1 block 25trees × 20 trees = 500 trees 、Spacing　6m×6m)

Gaciongo sub-PTS (2015planting)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
8	58f	60	24f	76f	70f	22	28	1f	22f	34f	61f	14	60f	37	39	70f	27	1	30f	11	8
7	43f	97f	41	39	2	49f	19	4	11	13	48f	36f	67f	35f	51f	7f	97f	31	72f	34	7
6	10f	5	43	61f	57	3	48f	3f	79f	17	6	29	11f	27f	8f	38f	17	4	43f	10	6
5	36	6	30f	10	33	55f	2f	31	7f	8f	2f	43	3f	7	91f	76f	32	57	20	33	5
4	9	54f	21	20	6f	21f	12	16	27f	25f	26	3	12	34f	5	100f	36	1	21	4f	4
3	67f	53f	51f	27	35f	7	65f	74f	12f	100f	46f	74f	79f	59f	6f	1f	12f	24f	41	40	3
2	4f	1	9f	26	34	5f	59f	14	40	29	53f	28	55f	9f	8	59	16	19	58f	13f	2
1	46f	8	37f	11f	32	60f	91f	72f	23	36f	2	65f	49f	60	10f	13	5f	23	22	9	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	

Gate

One line Guard row is outside: Clone12o.

Marimanti PTS **Date of Planting: 3rd Dec 2014**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
8	38	7o			17o	7o	1	38	76	48	38		4o	38	76		14	76	9	38
7	74	40f	74	39	48	37				9		40f	17o				7o	1	37	48
6	37	9		76	4o	40f	48	1	38	14	5	1	37	38	17o	4o	40f	9	38	9
5	38		37	74	7o			9		48	39		9	40f		74	37		7o	48
4	17o	4o	7o	17o	48		37		59	1	48		37	48	1	7o	14	9	37	
3	39		39			1	14	5	38	9	59	9		74		48	39	7o		76
2		9	14	40f	59		59	4o		76	48		17o	7o	4o	1	59	38	5	1
1	38	37	48	5	1	9	7o	37	1	5	1		59	39	5	37		14		

↑ 2015site

Old gate

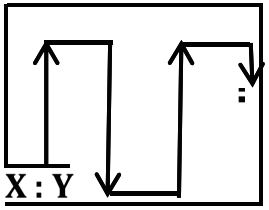
9	Clone ID Numbers
7o	ID7 the seed from old orcherd
4f	ID4 the seed from field
	Ordinary seedlings

1 line guard row

Block starting points

BLOCK	**X : Y**
Block I	1 : 1
Block II	1 : 9
Block III	1 : 17

Block Assessment direction



Marimanti PTS (2015planting)

PTS 2014 ↑

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
50	41	24f	91f	11f	70f	41	8	2	4f	35f	36f	51f	70f	49f	36f	10	7	3	50
49	9f	51f	14	6f	22	4	39	5	40	7	9f	5	27	61f	40	3f	14	6f	49
48	12f	19	49f	27	53f	97f	91f	14	21	41	29	12	2f	3	39	12	21	67f	48
47	13	31	67f	33	36f	13	10	11f	30f	11	13	33	74f	20o	30f	23	4	27f	47
46	2	61f	34f	32	8	16	19	55f	46f	4f	39	49f	70f	9	65f	8	41	31	46
45	11	57	51f	5f	100f	2f	31	23	3	2	34f	16	91f	36f	5	49f	19	11	45
44	53f	12	10	4f	70f	8f	27	48f	67f	14	32	2f	3	55f	22	16o	51f	10	44
43	76f	20	17	21	60f	24f	41	43	33	11f	31	17	4	9f	13	53f	4f	1	43
42	32	13	3f	16	36	11	17	4	29	5f	9	6f	7	33	61f	34f	8	74f	42
41	✕	6f	5	9f	55f	43f	7	23	57	91f	5	12	30f	2	9f	23	4	2f	41
40	9	10	41	12	34f	70f	76f	39	19	9f	51f	24f	3	20	40	19	27	32	40
39	19	76f	4	53f	31	2	40	22	11f	48f	34	2f	74f	97f	57	9	67f	3f	39
38	✕	14	33	29	10f	60	14	8f	3f	100f	40	8	31	32	27f	39	11f	30f	38
37	20	9	27	16	74f	✕	21	67f	20	61f	30f	34f	49f	10f	61f	8f	2	76f	37
36	17	12	4f	32	17	36	55f	9	74f	27	3	58f	16	91f	22	17	11	5f	36
35	13	40	8	20	6f	11f	39	5	24f	76f	7	1f	29	33	24f	21	55f	10	35
34	11	14	29	10	7	100f	✕	31	91f	51f	11	79f	10	9	36f	13	43f	34f	34
33	22	70f	27f	✕	30f	13	49f	41	3f	6f	70f	31	67f	12	41	4	49f	29	33
32	61f	51f	4f	67f	12	27	2	5f	53f	2f	16	5f	22	19	16	7	14	51f	32
31	76f	2f	20	8f	40	11f	57	24f	12	97f	46f	11f	55f	40	8	5f	33	58f	31
30	9	48f	32	19	✕	21	34f	14	33	✕	5	9	100f	61f	39	3	67f	8f	30
29	33	✕	27f	✕	✕	✕	55f	✕	✕	✕	8	51f	4	41	57	27	13	41	29
28	6f	✕	✕	53f	74f	10	✕	✕	✕	19	7	26	2.f	58f	20	11f	17	5	28
27	76f	4	✕	46f	12f	2	91f	9f	31	30f	✕	10f	49f	30f	31	55f	100f	53f	27
26	36	12	28	11	3f	13	20	11f	67f	32	✕	✕	✕	✕	✕	✕	✕	✕	26
25	8	2f	21	16	23	34f	12	34	39	40	17	✕	✕	✕	✕	✕	✕	✕	25
24	7	65f	70f	32	3	4f	76f	72f	49f	61f	20	59f	23	5	1	39	4	3	24
23	100f	33	60	10f	36	6	2	9f	24f	97f	29	10	7f	48f	21	25f	36f	9	23
22	5	57	76f	22	3f	60f	21	36f	51f	3	35f	91f	74f	76f	14	70f	9f	36	22
21	74f	29	19	91f	27	36f	6f	22	11	41	27	3f	1f	4f	19	17	7	31	21
20	55f	17	32	30f	39	70f	34f	23	4f	33	53f	22	32	31	6f	11	3	16	20
19	39	40	20	8f	9	12f	24f	5f	32	67f	16	30f	2	10	24f	27	34f	23	19
18	1f	6f	24f	3f	33	21	14	61f	2	36f	17	11f	34	9f	20	4	8	9f	18
17	4f	11	43	61f	22	5	40	48f	8f	74f	91f	8	55f	49f	74f	40	36f	13	17
16	5o	31	57	32	4	70f	55f	3	7	9f	27	19	4f	6f	51f	8f	33	5f	16
15	29	55f	23	2f	13	74f	76f	9	51f	70f	40	2f	24f	30f	14	76f	11	1f	15
14	20	39	3f	19	49f	41	1	10	13	12	22	5	17	21	12	29	17	10f	14
13	67f	11	30f	58f	34f	8f	16	31	38f	48f	91f	39	4	11f	32	26	31	27f	13
12	40	7	21f	36	67f	32	2f	20	57	100f	14	16	7f	18	10	43f	100f	67f	12
11	4	8	33	13	29	37	36f	76f	7	97f	2	41	9f	74f	2f	27	5f	19	11
10	39	57	27	61f	9	12	51f	70f	46f	47f	53f	22	30f	12f	23	58f	24f	9	10
9	36f	3	22	6	3f	23	10	74f	34	3	51f	4f	32	55f	72f	79f	41	20	9
8	21	6f	91f	5	24f	59f	39	12f	11	91f	11f	61f	48f	12	34f	8f	61f	100f	8
7	2f	7	2	55f	36o	2f	4f	13	54f	37f	20	43	10f	8	65f	14	4f	8	7
6	23	41	70f	33	53f	49f	60f	34f	25f	16	17	14	24f	76f	49f	29	6f	32	6
5	8	17	3f	9	8f	4	31	5	3	33	3f	29	21	27f	2	33	11f	53f	5
4	19	74f	61f	10	100f	74f	76f	97f	21	9f	4	30	55f	31	10	41	34f	17	4
3	16	27	22	60	36f	3f	5f	40	39	70f	20	91f	13	36	12	36f	9	91f	3
2	53f	40	1f	23	49f	65f	61f	6f	67f	28	8	19	22f	11	5	30f	49f	35f	2
1	59	46f	48f	67f	7	27	34	51f	14	11	10f	5f	2	13f	16	3	24f	40	1
Gate	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	

Two lines of guard row are outside of the line, one line of guard row of the row.

Out side of the line:Clone 17, inside of the line and row:Clone12

✕ These cell weren't planted in order to avoid gully

Makima sub-PTS (2015planting)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
8	10	3f	59f	14	36	7f	34	5	3	8	1f	4	14	29	1	48f	6	10	34	43f	8
7	23	67f	74f	10f	8f	17	4f	33	53f	70f	46f	13	27f	35f	16	59	5f	8	57	27f	7
6	2	79f	21	46f	1f	35f	9f	22	5f	55f	100f	72f	5	12f	10f	79f	49f	39	31	65f	6
5	6f	59f	60	43f	51f	12	25f	39	9	91f	30f	27	2	28	9f	36f	34f	24f	36	7	5
4	37f	27	26	54f	34f	30f	57	41	4	31	3f	13f	43	34	1f	4f	70f	55f	11f	91f	4
3	13	65f	2f	12f	48f	40	7	49f	1	19	33	97f	21	60f	61f	40	51f	67f	9	58f	3
2	58f	20	28	36f	72f	6	22f	43	29	32	53f	8f	37	23	19	20	65f	3	11	41	2
1	11f	100f	97f	11	16	60f	76f	21f	24f	61f	12	60	17o	76f	6f	97f	32	74f	22	2f	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	

One line Guard row is outside: Clone12o.

Gate

Tiva PTS **Date of Planting: 19th Dec 2014**

24	76	38	14	1	17o	59	9	4f	59	9	37	48	38	4f	9	59	2	9	48	14
23	59	4f	9	37	5		55	1	76		4f	7o	39	76	4o	37	14	37	17o	59
22	37	17o	55	76	7o	2	38	37	17o	5		1	2	9	38	9	4o	38	7o	5
21	48	14	52	4o	48		40f	4o	2	48	14	38	59	55	1	5	1	9		2
20	9	38	2	37	9	14	59	39	52	7o	4o	37	48	4o	14	48	14	4o	7o	37
19		1	17o	7o	39	52		37	1	17o	76	1	17o	5	9	37	7o	59	2	48
18	7o	14	52	40f	5	4o	48	4f	55	40f	9			14	48	2	1	4o	17o	38
17	38	5	48	37	38	2	76	9	7o	5	48	38	59	2	1	17o	9	7o	5	59
16	37	59	4f	72	9	20f	37	38	17o	59	1	37	60	9	59	4o	14	37	38	4o
15	76	60	17o	55	59	8		20o	8	57	2	4o	20o	35	14	2	9	17o	2	7o
14	74	3	40f	4o	14	48	22	2		71	20f	52	74	4f	9	48	7o	1	38	37
13	9	48	22	7o	5	55	76	1	5	3		39	76	17o	37	17o	2	14	4o	1
12	38	20o	8	44	60	30o	71	32	30o	3	17o	1	14		48	5	59	48	17o	5
11	2	72	35	52	40f	4o	44	38	37	30f	2	55	4o	48	17o	4o	9	2	14	38
10		7o	1	38	39	48	7o	72	35	14	40f	30o		20f	7o	37	7o	1	7o	4o
9	55	30f	32	57	22		30f	5	32	57	4f	74		9	14	38	14	37	38	59
8	17o	4f	2	9	17o	59	3	4o	44	48	71	30f	4o	8	5	4o	48	5	2	37
7	39		1	55	48	44	37	20f		22	30o	55	1	60	2	59	1	14	59	38
6	38	57	20f	32	76	2	15	34	55	74	37	7o	38	52		5	7o	5	48	17o
5	4f	76	49	59	52	17o	40f	3	8	32	57		8	74	7o	4o	59	9	2	37
4	30o	11	5	55	14	60	5	20o	9	22	20o	34	72	4o		38	17o	48	38	17o
3	15	25	7o	74	72	37	4f	71	52	60	18f	59	5	9	48	37	59	1	5	59
2	39	30f	35	32	15	40f	48	18f	2	57	35	25	14	20f	5	9	48	14	38	9
1	72	14	44	49	30o	38	30f	7o	20o	39	1	11	40f	22	1	4o	2	7o	1	17o
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

←2015site

Gate

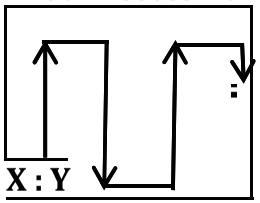
9	Clone ID Numbers
7o	ID7 the seed from old orcherd
4f	ID4 the seed from field
	Ordinary seedlings

1 line guard row

Block starting points

BLOCK	X : Y
Block I	1 : 1
Block II	1 : 9
Block II	1 : 17

Block Assessment direction



Tiva PTS (2015planting)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
36	16	39	10	70f	11f	3	76f	14	61f	12	20	6f	21	24f	40	7	20	41	10	39	1f	19	13	30f	**36**
35	4	23	53f	2	12f	20	16	30f	11f	19	40	31	76f	5	34f	43f	51f	2f	11f	11	67f	70f	33	27	**35**
34	32	31	91f	3f	27f	4f	11	55f	23	100f	3f	8f	11f	70f	33	16	48f	10f	3	34f	12f	5f	10f	100f	**34**
33	20	33	34	36f	61f	46f	9f	2	48f	39	32	74f	49f	13	36	53f	3f	30f	31	74f	21	8f	55f	5	**33**
32	13	7	17	55f	22	76f	7	91f	17	41	12	9	1f	21	8	10	14	4	19	5	49f	40	41	2f	**32**
31	11	2f	57	16	51f	29	5	4	40	14	29	22	76f	40	67f	74f	49f	17	91f	61f	27	8	17	9	**31**
30	31	9	27	24f	67f	23	35f	65f	10f	51f	10	27f	4f	61f	11	34f	9	8f	22	51f	14	13	4	6f	**30**
29	36f	91f	5	12	2	3	5f	21	16	36f	30f	7	31	13	55f	9f	16	76f	55f	3f	32	23	9f	29	**29**
28	67f	20	21	17	6f	41	8	22	3	8f	9	74f	6f	33	2f	79f	1	4f	58f	20	36f	2f	7	11	**28**
27	8	51f	32	19	4f	70f	72f	39	60	9f	12	14	53f	29	8	32	30f	2	49f	40	33	34f	49f	70f	**27**
26	61f	41	3f	2f	53f	10	11f	97f	24f	32	60f	22	27	24f	39	48f	57	12	91f	10	57	19	67f	6f	**26**
25	4	5f	100f	27	24f	9f	43	27	17	46f	2	36f	19	97f	34f	14	9f	7	21	41	22	3	39	74f	**25**
24	21	36	76f	8f	4	33	100f	34f	7f	55f	3	9	4	70f	2f	13	5	4f	27	3f	51f	48f	29	10	**24**
23	2	7	58f	23	17	11	67f	61f	6f	5f	91f	7	11	21f	40	74f	31	17	55f	40	24f	32	14	41	**23**
22	39	3f	6f	49f	20	2f	5	16	36	57	39	5	20	23	3	2	16	12	1	30f	36f	70f	19	8	**22**
21	12	24f	40	31	13	3	4f	25f	97f	10	33	13	11f	27	39	21	57	49f	5f	41	5	21	76f	100f	**21**
20	30f	100f	11f	10	70f	14	9f	76f	49f	4f	22	14	100f	2f	32	8f	10	11f	51f	27f	3f	49f	12	34f	**20**
19	11	5f	91f	34	2	61f	74f	48f	17	23	67f	9f	4	6	40	53f	76f	6f	91f	17	2	74f	32	22	**19**
18	53f	9	19	21	12	4	7	51f	8	36f	61f	7	41	26	1f	43f	9f	34f	67f	11	24f	61f	12f	9	**18**
17	9f	59f	7	33	3f	41	22	65f	10f	70f	40	46f	60	4f	2	16	33	14	30f	57	23	29	5	4	**17**
16	30f	32	55f	6f	36f	9	10	11f	4f	27	11	3	2f	27	31	3	11f	49f	20	4f	12	19	21	27	**16**
15	29	74f	31	97f	22f	34f	1f	32	55f	33	74f	9f	29	9	20	17	19	3f	53f	36	5f	72f	53f	30f	**15**
14	8f	24f	58f	14	8f	46f	24f	61f	39	13	36f	16	34f	8	28	36	34	67f	51f	91f	35f	55f	67f	41	**14**
13	22	48f	33	60f	19	43	20	91f	8	22	27f	79f	51f	39	76f	13	70f	8	10f	16	12f	10f	36f	31	**13**
12	10	8	13	39	41	5f	4	59f	11	5	21f	61f	48f	53f	22	36f	2	6	5	27	10	70f	100f	24f	**12**
11	29	2f	3f	61f	36	49f	7	9	12	67f	17	6f	32	31	21	41	34f	40	30f	38	74f	44	4f	22	**11**
10	9f	4	94f	9	1f	14	4f	40	39	2	33	36	97f	19	46f	11	55f	12	47f	3	21	13	35f	8	**10**
9	5f	19	74f	15f	53f	57	31	6f	55f	24f	23	8f	58f	25f	17	60f	20	19	67f	11f	20	91f	65f	12	**9**
8	23	34f	55f	72f	30f	2	13f	19	10	34f	100f	41	30f	10	2	57	2f	5f	10	7	4	39	67f	54f	**8**
7	2f	59	29	6f	3	41	11f	5f	20	21	8	22f	3	5	22	38f	8	31	9	70f	49f	76f	32	16	**7**
6	16	10f	14	11	12f	13	100f	76f	12f	43	39	9f	7	27	29	79f	16	7f	61f	43f	6f	19	9	36f	**6**
5	35f	61f	43	18	7	40	27	34	48f	51f	31	65f	11f	36f	21	20	9f	3f	24f	53f	34f	31	26	3	**5**
4	36	13	74f	53f	8f	3f	12	70f	5	14	74f	3f	2	23	4	100f	28	32	60	10f	1f	4f	33	57	**4**
3	70f	4f	51f	33	23	22	27f	91f	30f	16	27f	33	55f	8f	24f	51f	31	5	7	20	41	12	17	16	**3**
2	27	91f	1	32	67f	13	11	29	17	53f	9	40	32	34	76f	58f	49f	29	37	14	46f	40	37f	51f	**2**
1	43f	2f	3	49f	48f	39	6f	33	8	9f	60f	97f	11f	14	22	21	91f	17	23	8f	27	76f	36f	11	**1**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	

Two lines of guard row are outside. Inside:Clone12o, Outside:Clone14o ↓ **PTS 2014**

Yikithuki sub-PTS (2015planting)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
10	13	72f	49f	6	22	1	4	28	24f	36f	11f	48f	43f	13	5f	8f	10
9	7f	8	10f	60	51f	55f	2f	27	21	7	26	28	46f	67f	59f	12	9
8	21f	37f	100f	32	5	43	48f	59f	65f	8	35f	60f	76f	91f	60f	32	8
7	46f	27f	34	36	19	39	30f	34f	72f	19	97f	22	10	57	30f	27f	7
6	12	1f	2	12f	29	9	40	11	79f	74f	20	41	4f	3f	1f	49f	6
5	67f	21	10f	6f	20	7	25f	3f	2	70f	27	43	51f	6f	34	16	5
4	54f	22f	4f	76f	70f	97f	65f	10	1	31	35f	9	61f	14	40	58f	4
3	26	91f	23	33	74f	3	36f	14	34	13f	65f	4	3	11	2f	17	3
2	79f	16	31	24f	17	58f	5f	11f	53f	55f	100f	29	9f	6	33	37	2
1	53f	61f	43f	57	9f	8f	35f	41	43	23	5	36	60	12f	34f	39	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	

Gate

One line Guard row is outside: Clone12o.

Kibwezi PTS **Date of Planting: 16th Dec 2014**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
24	4f	38	37	9	59	48	14	37		9	76	2	59	7o	59	9		1	17o	
23	1	55	7o		17o	5	1	4f	39	38	17o	48	1	48	4f	5	7o	4o		38
22	7o	39	37		59	4o	59	38	55	14	39	37	38	7o	38	37	4f	55	14	4o
21	4o	48	76	9	37	9	48	14	17o	4o	38	4o	48	14	4o	1	5	59	48	5
20	17o		14	4o	17o	7o	1		7o	39	59		37	17o	5	9	48	1	9	38
19	1	39	76	48	14	76	48	37	48		17o	9	7o	38	7o	4o		4o	76	
18	14	9		38	55	4o	1		4f		38			1	17o	9	1	37	17o	7o
17	2	37		17o	9	5	39	37	38	17o	1	37	7o	9	7o	48	76	4f	4o	59
16	40f	1	32	4o	72			14		39	48	8	17o		53		13o	59		55
15		9		76		25	4f		9	37	76	74		1	7o	20f	8	4f	7o	9
14	17o	35		3		15	48	13o	20o		4f	53	13o	37		25				39
13	14	74	32	4o			22	53	40f		15	9			15	30o	32	48	20o	4o
12	59	39	5		17o		5		1	55	48	59	30f		20f		76	1	40f	
11	55	9	18f	53			39	74	57	17o	4o	8		55	71	5	9	57	38	60
10	3	76		7o	25	35	40f	22	59	20o	9	38	57			37	7o	3	14	9
9	38	14		74	22	34	55	9	5	13o	37	34	20f	9	38	18f	20o			
8		55	37	9	30f		1	2	57	39	72	35		60	74	55	5	32	48	4f
7	2	25			15	35	4o	3	48	71	32	59		37		39		17o	59	25
6	15		48	17o	51	40f	39	38		4f	34		2	18f	14	57	37	20f		20o
5	22	32		18f	38	8	72	7o	14	5	74		7o	55	53	40f		22	13o	60
4	13o	35	34	53	71	4f	9		53	18f		8	4o	76		20o	76	30f	40f	76
3		57	8	4o		13o		1	2	60	9	30f		5	38	4f	48	9	7o	4o
2	5			20o	14	34	20f		14	15	76		39	59	71			1	37	20f
1	30o	7o	38	25	17o			59		3	72	8		1	55	17o	20f	74	22	

Old gate

2015site →

48

9	Clone ID Numbers
7o	ID7 the seed from old orcherd
4f	ID4 the seed from field
	Ordinary seedlings

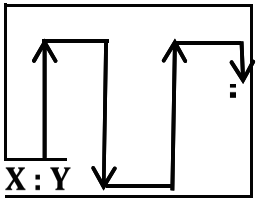
↓ ASS

1 line guard row

Block starting points

BLOCK X : Y	
Block I	1 : 1
Block II	1 : 9
Block III	1 : 17

Block Assessment direction



Kibwezi PTS (2015planting)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
44	39	14	61f	32	46f	24f	51f	40	1f	4	91f	43	76f	6f	1f	8f	30f	3	14	7	39	8	6f	14	44
43	41	74f	4f	76f	22	23	5	21	39	41	12	27	39	41	20	21	4	10	13	9	5f	21	29	31	43
42	19	16	34f	55f	17	33	2f	1	8f	14	3f	5f	22	51f	49f	91f	16	61f	27	2	24f	9f	11	4	42
41	17	12	57	70f	53f	41	31	43f	76f	10f	11	8	16	7	11	2	22	8	19	67f	30f	12	40	27	41
40	5	11f	61f	8f	40	100f	20	70f	32	9f	5	53f	70f	36	23	55f	36f	12	34f	31	74f	36f	76f	3f	40
39	7	32	20	10	21	51f	2	58f	36f	33	20	12f	30f	100f	97f	65f	6f	53f	41	5	58f	10	14	34f	39
38	74f	24f	67f	34f	33	49f	3	6f	91f	10	17	3	57	13	10	60	61f	12f	4f	29	48f	2f	8f	67f	38
37	2	39	2f	14	91f	36	27	41	19	11f	21	27	24f	9f	11	5	48f	51f	8f	17	16	46f	12	23	37
36	30f	31	13	4f	9f	24f	9	3f	53f	16	8	72f	40	55f	31	22	32	39	27f	22	76f	33	31	9	36
35	57	29	55f	21	17	60f	23	97f	36f	55f	33	36	49f	29	19	12	49f	3	7	9f	49f	35f	27f	13	35
34	74f	16	9	11	67f	22	28	100f	9f	70f	48f	3f	32	3	9	3f	13	40	19	5f	74f	3	40	30f	34
33	19	36f	2f	61f	51f	32	10f	91f	20o	6f	79f	4	7	67f	8	33	2	10f	17	34f	20	4f	70f	34	33
32							14	19	61f	12	76f	40	22	30f	41	16	100f	21	51f	53f	5	10	67f	2f	32
31							76f	10	74f	51f	23	49f	91f	5	11	97f	24f	79f	29	39	8o	9f	27	49f	31
30							39	21	60f	13	8f	3	2	36f	14	39	4f	9	48f	3f	74f	41	16	33	30
29							30f	5f	6f	33	100f	9	70f	19	9f	20	32	27	8f	36f	4	24f	13	11f	29
28							35f	19	41	14	12	21	29	51f	6f	23	31	76f	61f	22	6f	5f	55f	14	28
27							5	58f	61f	4f	20	34f	30f	41	10f	40o	30f	55f	33	11f	20	34f	53f	57	27
26							29	1f	10o	67f	16	27	74f	1	4	2f	5f	7	67f	10f	3f	5	29	19	26
25							4	2	12f	6f	36	22f	8	53f	13	24f	3	17	11	8	91f	1f	31	8f	25
24							72f	51f	7f	46f	29	23	36f	54f	22	32	43f	41	10	27	74f	4f	67f	3	24
23							23	91f	34f	100f	17	55f	70f	57	49f	2	20	61f	46f	33	48f	9f	2f	49f	23
22							7	11f	36f	49f	7	2f	91f	34f	6f	27	76f	70f	22	12	14	6	100f	36f	22
21							55f	21f	70f	24f	34	13	59f	9f	5	17	9	55f	4f	40	4	60	57	26	21
20							61f	4	97f	65f	32	3	8	11	4	40	27f	3f	8	2	32	23	43	33	20
19							16	31	19	30f	11f	12f	28	74f	2	67f	51f	48f	5f	91f	34	17	7	31	19
18							17	53f	39	2f	34f	16	3f	11f	32	20	53f	36	10	27f	12	9	10f	11	18
17							7	76f	40	11	22	4f	36	21	24f	9	39	31	70f	37f	13	25f	58f	21	17
16							15f	10	100f	29	6f	57	23	11f	10	40	33	100f	65f	3	16	8	53f	11f	16
15							36f	31	14	49f	33	20	25f	17	61f	43f	67f	6f	76f	4	26	7	55f	29	15
14							10f	20	9	5	34f	3	27f	41	13	38	57	22	27	7f	5	36f	3f	9f	14
13							12	1	40	41	7	5f	9	32	18	16	14	8f	2	9	11	40	43	14	13
12							30f	16	53f	48f	24f	16	29	97f	4	19	21	32	3	19	74f	57	34f	76f	12
11							23	55f	27	21	11f	74f	79f	72f	43	76f	24f	48f	12	31	49f	61f	21	12	11
10							3f	57	14	59	34	91f	36f	22f	12	51f	4f	100f	41	59f	13	1f	70f	19	10
9							5	17	22	1f	2f	27f	39	49f	10f	17	2f	67f	2	51f	35f	8	91f	27	9
8							33	31	20	70f	34f	100f	11	67f	2	20	36	53f	19	4	97f	34f	53f	9f	8
7							10	30f	7	6f	5f	51f	36	21	58f	8	6	91f	65f	9f	39	74f	23	11	7
6							61f	8f	11f	29	32	4	7	3	27	46f	4f	3f	7	40	12f	6f	28	47f	6
5							13	35f	55f	14	39	53f	60f	34	33	30f	11	38f	29	76f	70f	49f	8f	21f	5
4							9f	50f	19	22	9	8	54f	40	8f	70f	27f	36f	67f	32	37f	33	61f	13	4
3							5f	37	48f	2	21	12f	97f	22	55f	24f	11f	2	35	30f	46f	20	43f	39	3
2							24f	58f	41o	23	5f	36	13f	44	23	32	12	60f	31	13	2f	5	17	10	2
1							94f	27	16	17	3f	39	4f	11	74f	91f	2f	4f	41	22	60	8	51f	31	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	

Two lines of guard row are outsid Inside:Clone12o, Outside:Clone14o ↓ PTS 2014 Acacia seed stand →

Mombasa RD.

Voi sub-PTS (2015planting)

Gate →

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
8	5f	70f	20	12f	26	4f	1f	97f	6	61f	20	32	12f	11	9f	19	46f	43f	31	2f	8
7	8f	14	17	41	76f	36f	10	40	8	27f	74f	1f	13f	27	4f	3	100f	79f	22	57	7
6	16	55f	59f	7	34	33	100f	35f	48f	13	53f	59	43	91f	61f	40	33	55f	35f	17	6
5	65f	11	22	32	53f	31	11f	27	39	36	12	35f	48f	8	30f	76f	34f	5f	34	41	5
4	67f	19	43	60f	74f	6f	46f	91f	60	43f	7f	1	28	2	24f	21	43	7	39	9	4
3	1	58f	30f	29	25f	9	4	2	51f	21f	60f	97f	58f	4	36f	5	2f	8f	23	51f	3
2	10f	5	37f	12	3	54f	21	10f	23	57	26	29	65f	70f	27f	60	3f	10	49f	11f	2
1	3f	7f	49f	22f	34f	79f	9f	24f	28	72f	59f	6	16	13	36	14	67f	6f	72f	37	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	

One line Guard row is outside: Clone12o.

Kasigau PTS **Date of Planting: 17th Dec 2014**

9		38	9	8	20f	55		17o	55	48	37	5	7o	38	48	17o	37		48	38
8	7o	39	48		7o			76	38		48		9			59		40f		55
7	4o				14	38	8	37	40f			20f		14		9		4o		
6	14		9		4o	5	9	48	20f	9	38	8	39	1	20f	74	48	37	20f	59
5		38	1		74	7o		76	74			48					5	38	74	14
4		40f	48	17o			40f	37			76	9		55	76	7o		9		
3	59	9		37		59	14		5	55		4o	14	5	39	17o	40f	55	17o	8
2	37	5	74	76	4o		48	1				7o	1		4o	48			38	1
1	20f	48	38	1	39	9		17o		38		76	74	40f	38			9	37	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

↑ 2015site

Gate

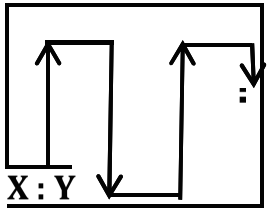
9	Clone ID Numbers
7o	ID7 the seed from old orcherd
4f	ID4 the seed from field
	Ordinary seedlings

1 line guard row

Block starting points

BLOCK X : Y
Block I 1 : 1
Block II 1 : 9
Block III 1 : 17

Block Assessment direction



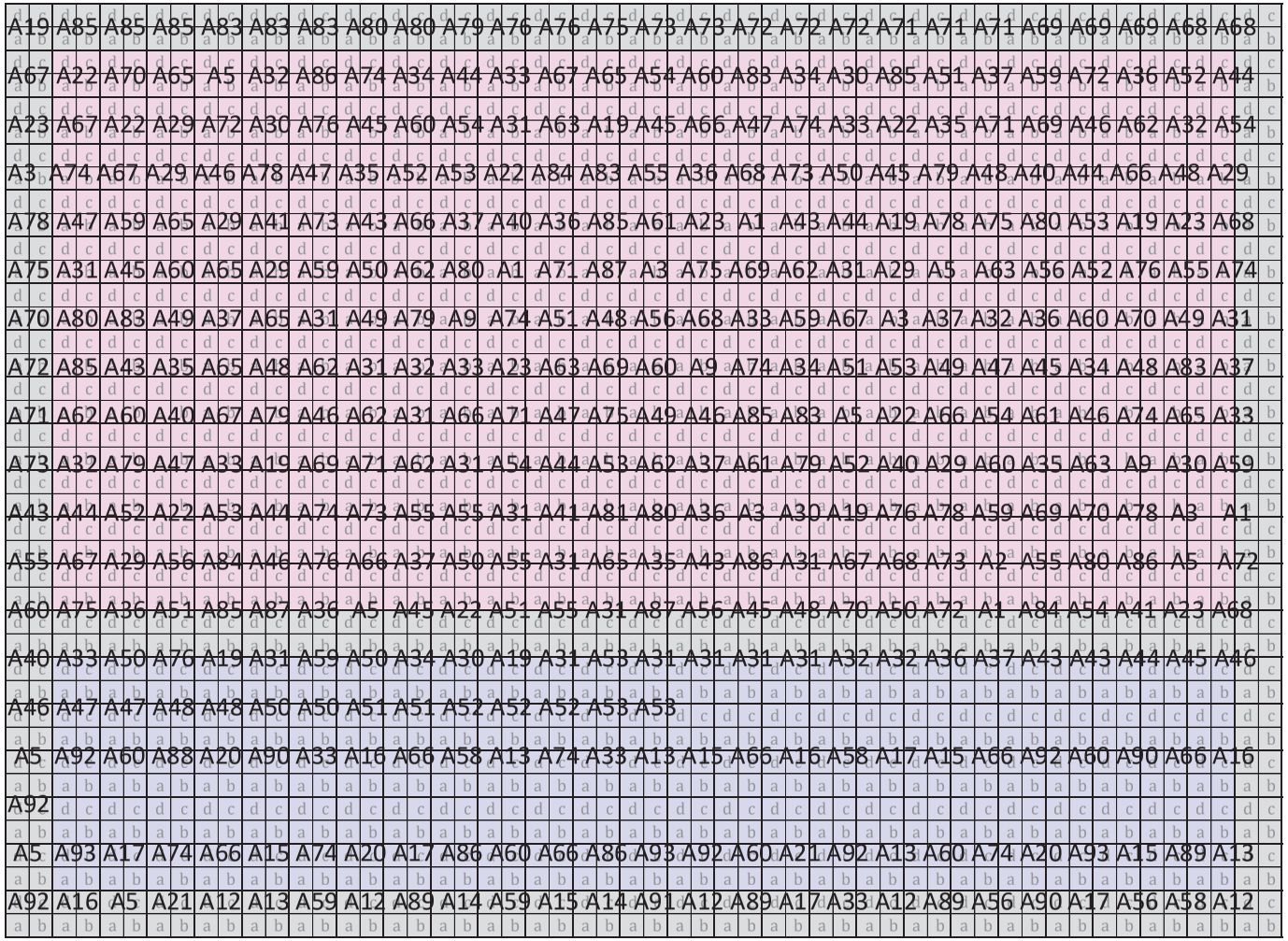
Kasigau PTS (2015planting)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
36	22	20	5	33	3f	1f	49f	51f	36f	2f	5	27	61f	48f	22	8f	14	11f	76f	97f	67f	32	4	57	36
35	55f	8	46f	1	16	60	11	41	40	39	12f	11	9	55f	9f	6f	21	3	13	9	12	3f	20	10	35
34	39	4f	12	70f	4	34f	31	6f	10	36	74f	3	97f	2	19	8	91f	23	24f	7	5	11	24f	21	34
33	3f	29	19	32	67f	9	29	30f	7	34f	21	20	67f	36f	13	33	17	2	31o	61f	2f	22	17	74f	33
32	8f	53f	7	22	5	12f	2	17	19	32	4f	17	8f	10	32	2f	11f	29	51f	14	70f	30f	16	36	32
31	49f	34	27	9f	13	91f	40	61f	22	33	10f	3f	43	70f	14	40	16	4	19	67f	40	39	41	27	31
30	6f	31	4	16	3	76f	74f	53f	3	11	74f	27	2	51f	5	10f	21	7	49f	43f	34f	11f	4f	8	30
29	4f	41	8	21	100f	2f	31	9	12	14	100f	36f	49f	20	100f	27	35f	53f	9	24f	55f	12	19	36f	29
28	74f	30f	10	67f	49f	7	30f	39	4f	76f	31	40	17	3	23	22	11f	20	41	5f	16	51f	29	2	28
27	65f	9f	48f	70f	24f	14	36f	91f	3f	70f	16	2f	19	13	91f	33	34f	76f	12	33	23	3	5	20	27
26	6f	14	61f	76f	5f	8f	34f	55f	41	58f	30f	57	10	41	12	61f	7	31	46f	6f	39	17	9f	24f	26
25	32	53f	39	91f	11	60f	23	13	10o	12f	27f	8	21	51f	9f	48f	10f	1f	2	9	8f	32	55f	40	25
24	10	22	21	8	3f	17	46f	5	9f	24f	49f	6f	11f	29	32	4f	30f	5	11f	49f	7f	3f	26	74f	24
23	33	3f	4f	20	12	6f	57	76f	34	2	14	36f	4	13	22	27	74f	55f	41	67f	27	13	2f	16	23
22	31	28	16	40	34f	19	67f	40	91f	74f	67f	11	40	1	17	70f	2f	20	39	4	3	7	23	9	22
21	9	51f	13	11f	2f	53f	48f	7	61f	3	58f	53f	12f	55f	91f	12	57	3f	34f	22	65f	31	61f	39	21
20	70f	21	22	41	36	29	11	49f	5	10	29	60f	20	49f	9f	46f	24f	16	8	70f	36f	100f	55f	20	20
19	8f	30f	100f	14	23	5f	8	70f	25f	41	4	8f	24f	19	5f	27	33	23	32	91f	27	8f	97f	32	19
18	2	74f	39	27	33	30f	12	36f	57	2f	10f	60	100f	8	4f	6f	61f	41	13	76f	49f	41	6f	10	18
17	61f	91f	9f	76f	20	55f	27f	7	61f	97f	67f	91f	31	76f	39	2	40	34	35f	14	3f	2	33	1f	17
16	36	51f	34f	16	21	4f	31	5	34f	14o	6	1f	9	53f	3	7	30f	43	11f	27f	31	51f	13	21f	16
15	10f	24f	53f	4f	11	59f	19	9f	4f	30f	4	36	11	32	67f	21	9f	16	10	3	17	22	32	19	15
14	5	2	10	23	9	2f	58f	39	17	12f	51f	48f	24f	29	33	70f	5f	51f	55f	19	43f	9	4	72f	14
13	22f	100f	33	17	11f	48f	76f	3	21	74f	40	79f	34f	3f	8	14	4	36f	11	6f	12	7	27f	11f	13
12	74f	5f	7f	70f	3f	14	100f	36f	23	46f	59	61f	28	16	4f	22	31	97f	100f	74f	13f	20	10	36f	12
11	65f	4	13	61f	49f	20	12	11	41	55f	11f	4	13	21	11f	76f	13	7	25f	16	33	5	29	74f	11
10	31	39	1f	19	9f	34f	40	5	27	19	7	29	32	9f	35f	55f	12f	9	34f	43f	70f	67f	39	91f	10
9	53f	7	29	16	44	33	30f	10	57	9	12	38f	31	17	11	3	32	3f	40	26	21	8	94f	27	9
8	22	5	8	47f	91f	76f	39	14	1	59f	53f	3	24f	2	30f	8	5f	61f	36	27	30f	11f	5f	40	8
7	18	17	2f	3	34	2	32	11	100f	76f	41	10	67f	5	6f	23	51f	31	21f	57	51f	22	76f	4f	7
6	37f	11f	13	19	23	54f	61f	36f	67f	5f	19	2f	36	16o	34	49f	13	29	4	27f	8f	100f	6f	17	6
5	41	27	14	40	67f	53f	51f	79f	58f	17	3f	23	72f	9f	21	74f	8f	7	21	91f	2f	10f	41	34f	5
4	9f	55f	20	35f	49f	48f	5	9	74f	20	61f	91f	36f	30f	58f	3	76f	32	24f	12	40	67f	3	70f	4
3	65f	22	34f	29	4	8	36	6f	33	41	49f	2	32	12	24f	51f	55f	8	33	14	27	48f	22	4f	3
2	39	7	2	91f	8f	39	60	10f	27f	43	16	48f	14	10f	19	10	46f	60f	43	70f	20	53f	1f	17	2
1	8f	37	33	36f	31	57	11	12	70f	97f	5f	23	9	2f	4	5f	21	9	6	22f	10	11	24f	6f	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	

Gate ↓ PTS 2014

Two lines of guard row are outside. Inside:Clone12o, Outside:Clone14o

Tiva *Acacia tortilis* seedling seed stand



Site layout and planting

- 2015year 25 plot × 4 trees × 5 blocks = 500 trees (25 families)
- 2016year 59 plot × 4 trees × 5 blocks =1,200 trees(59 families)
- Guard rows 460 trees Total 2,160 trees

Kibwezi *Acacia tortilis* seedling seed stand

line	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	row
	A19	A85	A85	A85	A85	A83	A83	A83	A83	A80	A80	A80	A79	A79	A76	A76	A75	A73	A73
27	A72	A22	A69	A54	A37	A32	A19	A76	A44	A85	A67	A69	A47	A45	A51	A19	A50	A35	A31
26	A51	A72	A22	A60	A74	A48	A46	A29	A83	A22	A45	A40	A66	A60	A36	A46	A37	A43	A44
25	A46	A45	A72	A22	A36	A34	A71	A66	A73	A55	A33	A74	A37	A50	A71	A53	A83	A74	A62
24	A60	A85	A36	A71	A29	A19	A80	A44	A75	A70	A43	A60	A36	A46	A59	A80	A68	A33	A75
23	A73	A48	A79	A67	A71	A29	A53	A67	A5	A31	A59	A53	A35	A31	A72	A44	A55	A54	A19
22	A76	A70	A47	A69	A37	A71	A29	A69	A51	A79	A50	A68	A78	A52	A65	A47	A22	A85	A67
21	A29	A31	A40	A71	A72	A32	A71	A31	A71	A23	A85	A45	A47	A51	A48	A50	A62	A34	A48
20	A65	A53	A78	A74	A65	A52	A23	A69	A31	A47	A37	A35	A34	A3	A74	A73	A19	A43	A63
19	A37	A45	A23	A46	A51	A55	A53	A19	A69	A31	A5	A72	A31	A75	A36	A54	A60	A45	A31
18	A59	A66	A49	A33	A36	A50	A37	A60	A36	A69	A31	A84	A55	A65	A83	A76	A52	A35	A23
17	A67	A79	A85	A52	A29	A62	A48	A47	A35	A54	A68	A31	A86	A59	A50	A69	A43	A53	A70
16	A5	A46	A44	A50	A47	A31	A71	A22	A75	A31	A85	A68	A31	A62	A23	A46	A80	A73	A79
15	A74	A75	A71	A68	A55	A19	A32	A67	A45	A79	A78	A80	A68	A31	A19	A74	A67	A60	A49
14	A59	A33	A62	A51	A66	A80	A74	A34	A46	A59	A74	A44	A53	A67	A31	A30	A70	A44	A78
13	A32	A45	A3	A83	A22	A76	A54	A78	A51	A76	A68	A47	A50	A66	A67	A31	A85	A87	A51
12	A22	A66	A41	A72	A30	A29	A65	A31	A37	A43	A60	A83	A19	A37	A48	A67	A31	A66	A40
11	A1	A29	A71	A9	A40	A48	A34	A60	A59	A1	A44	A67	A52	A72	A65	A45	A65	A31	A63
10	A60	A68	A48	A33	A56	A69	A36	A44	A32	A53	A36	A40	A69	A70	A5	A73	A74	A65	A31
9	A73	A49	A23	A67	A37	A59	A68	A74	A75	A66	A54	A5	A41	A49	A54	A29	A85	A69	A65
8	A31	A3	A84	A44	A62	A43	A45	A55	A86	A52	A61	A65	A35	A48	A3	A61	A1	A22	A80
7	A62																		
6	A31	A56	A53	A22	A30	A52	A60	A34	A63	A71	A46	A60	A85	A50	A52	A32	A45	A59	A84
5	A62																		
4	A32	A5	A70	A31	A76	A78	A46	A23	A49	A30	A22	A31	A51	A9	A76	A53	A62	A73	A47
3	A62	A32	A9	A54	A19	A50	A75	A2	A73	A9	A59	A33	A43	A41	A75	A79	A33	A78	A35
2	A36	A62	A32	A85	A40	A48	A35	A41	A86	A44	A40	A32	A69	A72	A47	A37	A74	A66	A51
1	A31	A40	A55																
9	A36	A47	A74	A32	A55	A1	A69	A87	A19	A50	A56	A83	A48	A54	A56	A83	A72	A5	A46
8	A55	A37	A29	A79	A81	A51	A36	A65	A67	A37	A82	A1	A78	A45	A30	A71	A55	A23	A19
7	A67	A55	A37	A83	A61	A87	A68	A34	A66	A70	A53	A33	A36	A79	A80	A86	A63	A34	A87
6	A59	A70	A53	A43	A63	A33	A72	A38	A71	A80	A3	A29	A2	A62	A84	A76	A60	A68	A65
5	A33	A43	A44	A53	A43	A43	A44	A44	A45	A46	A46	A47	A47	A48	A48	A50	A50	A51	A51
4	A51	A52	A52	A52	A53														
3	A5	A92	A12	A58	A17	A89	A12	A56	A66	A91	A58	A14	A60	A74	A56	A93	A88	A91	A15
2	A92																		
1	A5	A13	A91	A14	A21	A16	A14	A33	A93	A88	A21	A89	A17	A88	A92	A16	A12	A92	A56
	A92																		

Planted in Dec.2016
Planted in Apr.2015

Site layout and planting
・2015year　26 plot × 4 trees × 6 blocks ＝　624 trees (26 families)
・2016year　(60 plot × 4 trees × 6 blocks) + (63 plot × 4 trees × 2 blocks)=1,944 trees (61 families)
・Guard rows 528 trees　　Total 3,096 trees

Appendix 5 Dispatched short-term experts (Component 4)

Month/Year	Name	Expertise subject and Appendix No.				Other issues
		Project management	Drought tolerance	Artificial crossing	Tree breeding	
Sep.2017	Mr.Kamizore	5-1-1				
	Dr.Gyokusen		5-2-1			
	Dr.Goto		5-2-1			
Nov.2017	Mr.Kamizore	5-1-2				PMU Meeting / JCC Meeting
Dec.2017	Dr.Hanaoka			5-3-1		
	Dr.Matsushita			5-3-1		
Jan.2018	Mr.Kamizore	(5-4-1)				
	Dr.Miyashita				5-4-1	
	Mr.Hashimoto				5-4-1	
	Mr.Takakura				5-4-1	
	Dr.Gyokusen		5-2-2			
Apr.2018	Mr.Kamizore	(5-4-2)				
	Mr.Hashimoto				5-4-2	
May.2018	Mr.Kamizore	(5-3-2)				Melia Promotion Seminar (component 2)
	Dr.Matsushita			5-3-2		
Jun.2018	Mr.Kamizore	(5-3-3)				1st Project Interaction Workshop
	Dr.Matsushita			5-3-3		
Jul.2018	Dr.Ubukata	5-1-3				JCC Meeting
	Mr.Kawashima	5-1-3				
	Mr.Kamizore	(5-4-3)				
	Dr.Miyashita				5-4-3	
Sep.2018	Dr.Gyokusen		5-2-3			
	Dr.Goto		5-2-4			
Nov.2018	Mr.Kamizore	5-1-4				
Dec.2018	Dr.Hanaoka			5-3-4		PC Programme Seminar on Statistical Data Analysis
	Dr.Matsushita			5-3-4		
Feb.2019	Dr.Ubukata	5-1-5				JCC Meeting
	Mr.Kamizore	5-1-5				Mid-term review mission

The contents of the number which in the () is included in other reports.

Appendix 5 Dispatched short-term experts (Component 4)

Month/Year	Name	Expertise subject and Appendix No.				Other issues
		Project management	Drought tolerance	Artificial crossing	Tree breeding	
May.2019	Mr.Ichikawa	5-1-6				PMU Meeting
	Mr.Kobayashi	5-1-6				
	Mr.Kamizore	5-1-6				
Jul.2019	Dr.Ubukata	5-1-7				2nd Project Interaction Workshop
	Mr.Ichikawa	5-1-7				
	Dr.Miyashita				5-4-4	
Aug.2019	Dr.Hanaoka			5-3-5		PC Programme Seminar on Statistical Data Analysis
	Dr.Matsushita			5-3-5		
Sep.2019	Dr.Gyokusen		5-2-5			
Nov.2019	Mr.Kobayashi	(5-4-5)				
	Mr.Takakura				5-4-5	
	Mr.Furumoto				5-4-5	
Dec.2019	Dr.Matsushita			5-3-6		
Jan.2020	Dr.Ubukata	5-1-8				JCC Meeting
	Mr.Ichikawa	5-1-8				
Feb.2020	Mr.Kobayashi	(5-4-6)				
	Dr.Miyashita				5-4-6	
	Dr.Gyokusen		5-2-6			
Internal work report						
Aug.2021	Dr.Gyokusen		5-2-7			
	Mr.Kobayashi				5-4-7	
	Dr.Miyashita				5-4-8	Lecture of Rogueing
	Dr.Fukatsu				5-4-8	

The contents of the number which in the () is included in other reports.

Appendix 5-1-1~8

Dispatched short-term experts (Component 4: Tree Breeding)

【Project Management】

Appendix 5-1-1

Report of short term expert (Project management)

Expertise	Name	Term
Project Management	Mr. Shizuo Kamizore	5～18 Sep. 2017

1. Itinerary

Date	Activity
5 Sep. (Tue.)	Hitachi to Haneda, move to Dubai
6 Sep. (Wed.)	Arrival at Nairobi via Dubai
7 Sep. (Thu.)	Meeting with Japanese experts Courtesy call to CP in Ministry of Environment and Natural Resources
8 Sep. (Fri.)	Meeting with KEFRI CP Meeting with Japanese experts
9 Sep. (Sat.)	Making report
10 Sep. (Sun.)	Making report Move to Kitui with Kyushu univ. team
11 Sep. (Mon.)	Observation of Kitui nuesery
12 Sep. (Tue.)	Observation and study in Melia seed orchard
13 Sep. (Wed.)	Study on seedling plantation of drought tolerant clones in Tiva
14 Sep. (Thu)	Move to Nairobi Meeting with DG of KEFRI
15 Sep. (Fri.)	Making report Reporting to JICA Office
16 Sep. (Sat.)	Move to Dubai
17 Sep. (Sun.)	Dubai to Haneda
18 Sep. (Mon.)	Haneda to Hitachi

2. Result of major activities

2.1 Working plan of Component 4 (Tree breeding)

Working plan of Component 4 for 4 years-activities of tree breeding was discussed and approved in KEFRI CPs and Japanese experts. Especially the implementation structure, which indicated responsible persons for each activity and the management, was recognized as the important matter so that the tree breeding activities would be conducted and implemented appropriately in KEFRI and FTBC. It, therefore, is very important to keep in touch with KEFRI CPs and FTBC staffs through close contact between the project manager, site manager of KEFRI and a coordinator of FTBC.

Tree breeding activities of Component 4 have been conducted through dispatch of short term experts from FTBC and guidance of tree breeding techniques to KEFRI CPs., and FTBC should consider season and term of dispatching experts to take effective and efficient activities with CPs.

2.2 Study on drought tolerance of Melia by Kyushu university team

Kyushu university team has engaged in making indicators of drought tolerance for Melia since the former tree breeding project in Kenya. This program is included in activities of Component 4, CADEP and it is one of the important matter for decision of superior Melia clones. A coordinator of FTBC, Mr. Kamizore, joined the study to attend the activities of the team.

2.3 Observation of Melia seed orchard and Acacia seed stand

The leaves of almost trees in seed orchard have fallen because of in dry season. Dr. Gyokusen recommended clone 40 of Melia for superior individual with fast growth and good shape of crown.

The growth of Acacia is faster than expected and some of Acacia trees have stand with straight up so that a support of pole is not needed. An Acacia tree that was planted in 2012 on nursery site of Kitui center blossomed beautifully, and it could indicate that early seed production of Acacia, less than 5 years, would be succeeded.

3. Subjects for management

- Implementation structure is the most important issue in the project and it should be required that FTBC coordinate a schedule for dispatch of short term experts with KEFRI CPs. Some logistics matter such as hotel booking and car arrangement can be coordinated by the project in accordance with a detailed plan.
- The management of all sites, Melia seed orchards, Acacia seed stands and all progeny test sites, can be conducted by a site manager as a head and some responsible CPs who observe all sites periodically. The budget for the appropriate maintenance of the sites can be provided from the project, however, it must be considered how to reduce the maintenance cost by KEFRI and FTBC.
- It was conveyed from a staff of JICA Kenya office that KEFRI was going to get the 2017 JICA Recognition Award, which is to honor individuals or organizations for their long-standing contribution to JICA's activities in Japan or overseas.

4. Contact persons

Mr. Hewson Kabugi, Director of Forest Conservation, Ministry of Environment and Natural Resources
Dr. Gabriel Muturi, Component manager of CADEP, KEFRI
Dr. James Ndufa, Director of KEFRI Kitui regional station, KEFRI
Mr. Jason Kariuki, Assistant Component manager of CADEP, KEFRI
Mr. Paul, Forester, KEFRI
Mr. Shinjiro Amameishi, JICA Kenya Office
Ms. Miharu Furukawa, JICA Kenya Office
Mr. John Gugi, Senior program officer, JICA Kenya Office
Mr. Kenichi Takano, Chief Advisor, CADEP
Ms. Yuki Honjo, Coordinator, CADEP
Ms. Naomi Matsue, Forestry Extension, CADEP
Mr. Shinji Ogawa, short term expert for Forestry Extension, CADEP

Photo

Photo 1. Grafted seedlings for study on drought tolerance (Mr. Muchiri, Dr. Gyokusen and Dr. Goto from

Photo 2. Analysis and guidance of photosynthesis (Mr. Muchiri and Dr. Goto)

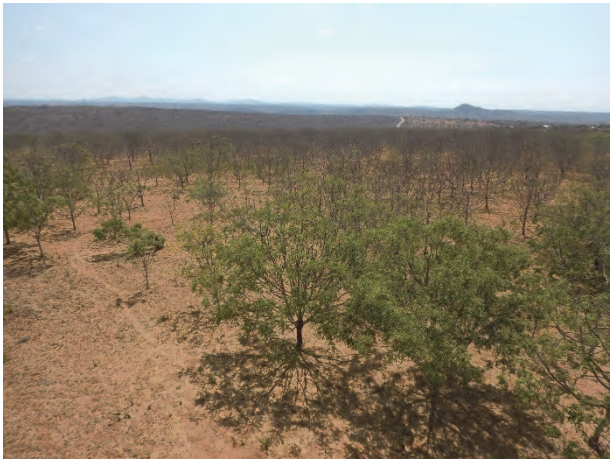


Photo 3. Melia seed orchard in Tiva (taken at a tower)

Photo 4. Edge trees of seed orchard

Photo 5. Melia Clone NO.40 in seed orchard (7m height)

Photo 6. Acacia seed stand in Tiva (4m height, no need to support with pole)

Photo 7. Acacia seed stand (planted on Dec. 2015)

Photo 8. Acacia on nursery of Kitui center (5 years old with blossom)

Photo 9.　Blossom of Acacia

Appendix 5-1-2

Report of short term expert (Project management)

Expertise	Name	Term
Project Management	Mr. Shizuo Kamizore	25 Nov. ～ 8 Dec. 2017

1. Itinerary

Date	Activity
25 Nov. (Sat.)	Move to Haneda, Haneda to Doha
26 Nov. (Sun.)	Arrival at Nairobi via Doha
27 Nov. (Mon.)	Meeting with Japanese experts Attendance at Project Management Unit meeting
28 Nov. (Tue.)	Making presentation material for JCC meeting Meeting with KEFRI CPs
29 Nov. (Wed.)	Move to Kibwezi Observation of Melia seed orchard and progeny test sites (PTS)
30 Nov. (Thu.)	Move to Kasigau Observation of Melia PTS and move to Kitui
1 Dec. (Fri.)	Observation of Melia seed orchard and PTS in Kitui Move to Marimanthi and observation of PTS, move to Nairobi
2 Dec. (Sat.)	Making presentation material for JCC meeting
3 Dec. (Sun.)	Making presentation material for JCC meeting
4 Dec. (Mon.)	Meeting with Japanese experts Meeting with KEFRI CPs
5 Dec. (Tue.)	Attendance at JCC meeting Meeting with Japanese experts
6 Dec. (Wed.)	Meeting with KEFRI CPs Move to Doha
7 Dec. (Thu.)	Doha to Haneda
8 Dec. (Fri.)	Move to Hitachi

2. Result of major activities

2.1 Project Management Unit (PMU) meeting

PMU meeting was held to exchange information of activities on each component, and the responsible CP explained the activity over the one year. FTBC explained the work plan, in which all activities of Component 4 (tree breeding) for 4 years were included, and breeding effect on Melia analyzed in the former project. The breeding effect is important factor to explain the advance of Melia and it was recommended that the effect is introduced in extension activities of Component 2.

2.2 Joint Coordinating Committee (JCC) meeting

2nd JCC meeting was held in Ministry of Environment and Natural Resources chaired by Mr. Gathaara, conservation secretary of the ministry. The CP in charge of each component explained the activity of previous year and a plan of the next year for each component. Dr. Muturi, who is a manager of Component 4 (Tree Breeding), explained the activities on tree breeding for 4 years and results of the former project based on the material that was introduced in PMU meeting from FTBC.

Amendment of the Project Design Matrix (PDM) concerned with Component 4 was proposed in accordance with the new activities, which are focused on tree breeding research and do not involve extension activities such as establishment of Melia local seed orchards and technical training for seedling producers. This amendment was approved by the JCC members. it was mentioned that FTBC would take technical supports for the local seed orchard or training course, if it would be needed.

Dr. Chagara, who is a manager of Component 5, proposed that a work shop should be held to collaborate with each component efficiently. The work shop is planned to be possibly held on Jan. 2018 with all component managers.

2.3 Observation of sites

I observed all sites except sub-PTSs with a CP in charge of site management.

1) Kibwezi

・Melia seed orchard

A few glass was remained on the ground of seed orchard since complete weeding was undertaken 2 weeks before. It could be considered to take more efficient measure for cost reduction, for example line weeding or spot weeding near trees.

・Melia PTS (DBH:8-10cm, H:4-6m planted on Dec.2014, DBH:10cm, H:4-7m planted on Dec. 2015)

Height growth of trees planted Dec. 2014 was slower than trees planted 2015. It could be caused by the soil condition or structure, and soil analysis would be necessary to identify the reason.

・Acacia seed stand (H:2-4m planted on Dec.2014, H:1-2.5m planted on Dec. 2015)

The growth was healthy to reach 4m height and some trees could stand independently with no support of pole.

2) Kitui

・Melia seed orchard

Complete weeding was undertaken 2 weeks before as well as Kibwezi site.

・Melia PTS (DBH:10-12cm, H:6-8m planted on Dec.2014, DBH:8-10cm, H:5-7m planted on Dec. 2015)

A lot of trees planted on Dec. 2015 had been supported by poles to guard them from strong wind, and it was not necessary so far for healthy growth of trees. There, however, were few trees that roots were damaged by wind and fell down.

・Acacia seed stand (H:2-5m planted on Dec.2015, H:1-3m planted on Apr. 2016)

Growth of trees was better than Kibwezi and some trees could stand independently with no support of pole. The difference of growth between trees planted 2014 and 2015 was quite big than expected, and it could be caused by having one more in rainy season.

3) Kasigau

・Melia PTS (DBH:10-12cm, H:4-7m planted on Dec.2014, DBH:6-8cm, H:3-6m planted on Dec. 2015) It was necessary for some trees to be supported by poles because of frequent strong wind from southern mountain for one more year.

4) Marimanti

・Melia PTS (DBH:10-18cm, H:7-8m planted on Dec.2014, DBH:6-10cm, H:4-7m planted on Dec. 2015) Diameter growth was better, but height growth would be stopped on trees planted Dec. 2014. Growth of tree planted on Dec. 2015 was healthy, and appropriate bud pruning was implemented.

3. Subjects for management

・The maintenance cost 500,000 Ksh a month for Melia seed orchards, Acacia seed stands and PTSs have been supported by the project budget. It is the most important matter to reduce the cost immediately, in which security and weeding have occupied more than 50% of it. KEFRI has just started reducing the weeding cost depending on line or spot weeding but a suitable and specified measure could not be found so far. It is also needed to request strongly regular budget for the maintenance, especially security, to KEFRI.

・In this Japanese fiscal year, short term experts in the field of breeding research and propagation will be dispatched from FTBC and an expert of drought tolerance will be dispatched from Kyushu university on Jan. 2018. FTBC is going to arrange the schedule with KEFRI CPs.

・The next JCC meeting is planned to be held on Jul. 2018 as usual. FTBC will dispatch short term experts, project management, to attend the meeting and explain the results of tree breeding activities. Data of PTSs assessment measured on Jan. 2018 will be analyzed as soon as the data will be prepared.

4. Contact persons

Mr. Gideon Gathaara, Conservation secretary, Ministry of Environment and Natural Resources
Mr. Hewson Kabugi, Director of Forest Conservation, MENR, manager of Component 1
Mr. Gordon Sigu, Senior researcher, MENR
Mr. Peter Nduati, Deputy director, Kenya Forest Service, manager of Component 2 and 3
Dr. Gabriel Muturi, Senior deputy director, KEFRI, manager of Component 4
Dr. Ebby Chagala-Odera, Deputy director, manager of Component 5
Mr. Jason Kariuki, Assistant Component manager of CADEP, KEFRI
Mr. Paul, Forester, KEFRI
Ms. Keiko Sano, representative of JICA Kenya Office
Ms. Yoko Okonogi, JICA Kenya Office
Mr. John Gugi, Senior program officer, JICA Kenya Office
Mr. Kenichi Takano, Chief Advisor, CADEP
Ms. Yuki Honjo, Coordinator, CADEP
Ms. Naomi Matsue, Forestry Extension, CADEP
Mr. Kazuhisa Kato, Executive director, Japan Overseas Forestry Consultants Association

Photos

Photo 1. Project Management Unit meeting (Dr. Muturi as a chairman)

Photo 2. JCC meeting (Dr. Muturi explained tree breeding activities)

Photo 3. JCC meeting (Chairman Mr. Gathaara, Ms. Sano on the right of Mr. Gathaara)

Photo 4. Melia seed orchard in Kibwezi (weeded 2 weeks before)

Photo 5. Melia PTS in Kibwezi planted Dec. 2014 (weeded on the left, not weeded on the right, not good for growth)

Photo 6. Melia PTS in Kibwezi planted on Dec. 2015

Photo 7. Acacia seed stand in Kibwezi planted on Dec. 2015

Photo 8. Acacia seed stand in Kibwezi planted on Apr.2016

Photo 9. Melia seed orchard in Tiva

Photo 10. Melia seed orchard in Tiva (taken from observation tower)

Photo 11. Melia PTS in Tiva planted on Dec.2014

Photo 12. Melia PTS in Tiva planted on Dec.2015

Photo 13. Fallen tree in Melia PTS of TIVA planted on Dec. 2015

Photo 14. Acacia seed stand in Tiva planted on Dec. 2015

Photo 15. Acacia seed stand in Tiva planted on Apr. 2016

Photo 16. Acacia seed stand in Tiva (taken from observation tower, front for 2015 planted, back for 2016)

Photo 17. Melia PTS in Kasigau planted on Dec. 2014

Photo 18. Melia PTS in Kasigau planted on Dec.2015 (adjusting the stem by string)

Photo 19. Melia PTS in Marimanthi planted on Dec. 2014

Photo 20. Melia PTS in Marimanthi planted on Dec. 2015

Appendix 5-1-3

Report of short term expert (Project Management)

Expertise	Name	Term
Project Management	Dr. Masatoshi Ubukata	2018.7.14～7.21
Project Management	Mr. Yutaka Kawashima	2018.7.14～7.21

1. Itinerary

Date	Activity
14 Jul. (Sat.)	Move to Haneda
15 Jul. (Sun.)	Move to Dubai, arrival at Nairobi Meeting with Japanese experts
16 Jul. (Mon.)	Meeting with KEFRI CPs Move to Kitui
17 Jul. (Tue.)	Observation of Melia Seed Orchard, PTS in Tiva and nursery in Kitui center Move to Nairobi
18 Jul. (Wed.)	Meeting with KEFRI CPs Courtesy call to Director of KEFRI
19 Jul. (Thu.)	Attendance at Joint Coordinating Committee (JCC) meeting Move to Dubai
20 Jul. (Fri.)	Move to Haneda
21 Jul. (Sat.)	Move to Hitachi

2. Results of major activities

2.1 Meeting with Dr. Muturi, KEFRI Component 4 manager

The management of project sites, Melia seed orchard, progeny test sites and Acacia seed stand, was discussed with Dr. Muturi. The management cost shard from JICA will be decreasing year by year, and it was mentioned that KEFRI requested the financial department to budget 1.2 million development fund that would be prepared for the project site management.

KEFRI has a management plan through Private-public Partnership as a collaboration with private sector such as KOMAZA and Better Globe Forestry after the JICA project will finish. Traceability of improved seed and seedling can be ensured in MOU and MOA, and it is possible to identify the origin of Melia tree by DNA analysis using specific markers that the former project has already developed.

According to Forest Management and Conservation Act 2016, KEFRI shall be responsible to establish Melia local seed orchards which county government will request.

2.2 Observation of KEFRI Seed Centre

KEFRI Seed Centre has 3 branches in Kenya and is in charge of seed collection, extraction seeds, quality control consisting of germination, purity and moisture control, and sales for 200 species. A price of Melia seed is 4,500Ksh/kg for ordinary and 6,000 for improved seed. Melia improved seeds

100kg was distributed to Better Globe Forestry last year for 200kg demand, and the demand from local farmers is raising gradually. The income from sales must be paid to the national treasury, and it seems that KEFRI is able to get no income directly through the sales.

2.3 Meeting with Dr. Ndufa, Director of KEFRI Dry-lands Eco region Research Centre Kitui

KEFRI has 5 Eco region Research Centers, and this Kitui center has established in 1986 originally. It covers 9 counties and about 52% of total land of Kenya. Melia, Acacia and Termnalia have advantages for plantation in this order.

Concerning private sectors for Melia seed production, KOMAZA could become not only a partner but a competitor for a Melia improved seed producer when KOMAZA would establish an own Melia seed orchard. Demand for Melia plantation in Kenya has grown over in recent years, so production of quality Melia seeds is considered as a good business. KEFRI has a plan that some breeders will be dispatched to establish a seed orchard with getting consultant fee from KOMAZA.

KEFRI has about 50 researchers in headquarters and Kitui Center has 14 researchers including branches. The age group of 50's has been in large number, which could cause to restrict new employment.

Concerning security against project sites, 8 farmers have been employed for security to guard the sites from nomads and other invaders by 500Ksh. a day. Dr. Ndufa has a plan that more strong-built fences should be set to make security more efficient.

2.4 Observation of Tiva site

As for Melia seed orchard, 100kg of fruits were harvested in 2017 and 400kg (4000-4500 seeds can be collected from 1kg fruit) harvesting is expected in 2018. Mr. Takano, chief advisor of CADEP, explained that the matured fruits must be harvested before dropping and the height of Melia tree grew too higher to harvest fruits. Concerning cost down of weeding, weed-killer cannot be introduced because of negative influence to Melia fruits and some vegetation on agroforestry, and bush cutter takes much maintenance fee. The cost of weeding is 80,080Ksh totally or 24,266Ksh/ha a year.

As for Melia progeny test site, weeding is carried out after rainy season for prevention against pest and disease, and the assessment of PTS. Mr. Takano explained that no bad influence to no weeding in private Melia plantation on the same age. A forester suggested that thinning could be needed because of piling of the crowns.

JICA mission team requested KEFRI to prepare counter budget for maintenance cost on project sites and explained that activities on component 4 would be restricted in accordance with the counter budget.

2.5 Attendance at Joint Coordinating Committee meeting

Ms. Susan Mochache, first secretary of the Ministry of Environment and Forestry, made an opening address, which expressed that Kenya has respected Japanese sincere cooperation in the field of forest and forestry. Ms. Sano, chief representative of JICA Kenya Office, expressed necessity for Kenyan counter budget preparation to the project, and Ms. Kenmiya, head of JICA mission, explained that internal evaluation on the project would be implemented on the next year and requested preparation of the necessary budget to implement the project activities as an opening address.

Under being chaired by Mr. Kabugi, manager of CADEP, the result and plan on the activity of each component was explained by each component manager. After discussion on the activities, Mr. Takano explained change of the annual plan and it was consented with the JCC members.

3. Subjects for project management

Each activity of tree breeding on Compo.4 has been proceeded successfully through cooperation with KEFRI CPs. It was also confirmed that compo.4 should provide technical supports for construction of local seed orchards and the establishment of regulations on distribution of improved seeds through advices from FTBC.

FTBC was requested from JICA mission team as follows;

・Cost sharing by KEFRI on management of project sites shall be clarified, and measures for reduction of the cost shall be made in the interim evaluation.

・The plan of second generation development on Melia after termination of the project shall be established in the end of project term.

・Short term experts shall be dispatched with appropriate term to implement all activities of Compo.4 efficiently and effectively.

Photo

KEFRI Seed Centre

Greenhouse in KEFRI Seed Centre

Room for seed quality control in Seed centre

Seed storage room in Seed centre

Inside of laboratory in KEFRI

Experiment instruments in KEFRI

Melia seed orchard in Tiva (explained by Dr. Ndufa, Director of Kitui reginal centre)

Melia seed orchard in Tiva

Flowring of Melia (Tiva seed orchard)

Fruits of Melia (Tiva seed orchard)

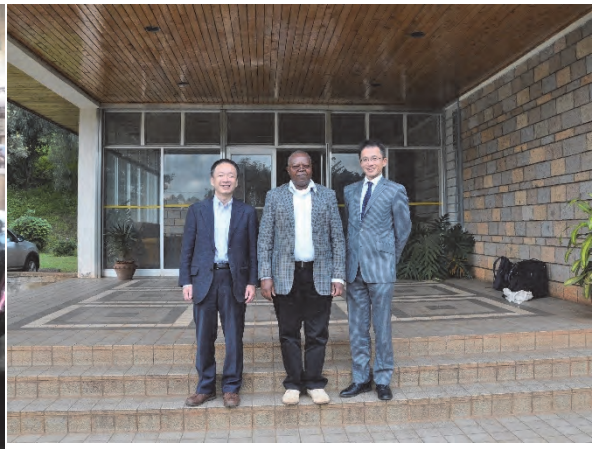
Progeny test site for Melia in Tiva

Artificial crossing test in Melia seed orchard

Acacia seed stand/Progeny test site

Wire mesh fence aound the site

3rd Joint Coordinating Committie (JCC) Meeting



Dr. Ndufa, Director of KEFRI Kitui reginal station

Appendix 5-1-4

Project Management

Field	Name	Term
Project Management	Mr. Shizuo Kamizore	2018.11.20～11.29

1. Schedule

Date		Contents	Stay
20 Nov. (Tue.)		Move (Hitachi to Haneda)	
21 Nov. (Wed.)		Move (Haneda - Doha - Nairobi） Move to Kitui	Kitui
22 Nov. (Thu.)		Study on Melia cutting (Collecting scions and treating)	Kitui
23 Nov. (Fri.)		Study on Melia cutting (Cutting and putting cutting pots)	Kitui
24 Nov. (Sat.)	AM PM	Study on Melia cutting (Checking cutting pot in a greenhouse) Observation of Melia seed orchard and Acacia seed stand, Move to Nairobi	Nairobi
25 Nov. (Sun.)		Documentation	Nairobi
26 Nov. (Mon.)	AM PM	Meeting with CPs in KEFRI Meeting with CADEP Japanese experts	Nairobi
27 Nov. (Tue)	AM PM	Meeting with CADEP Japanese experts Move to airport, Move (Nairobi - Doha)	
28 Nov. (Wed.)		Move (Doha - Haneda)	Haneda
29 Nov. (Thu.)		Move (Haneda - Hitachi)	

2. Results of major activities

2.1 Study on Melia cutting

It was found that no callus formation and rooting for Melia cutting study on Apr. 2018 was unfortunately confirmed. The result could be caused by low temperature on long time rainy season and so on. In this time, we conducted the cutting study using new green branches in seed orchard and new sprouts from PTS as scions, which has been used for Japanese Melia cutting study and succeeded with rooting (refer to Attachment).

New branches that has grown well for 4 clones in seed orchard were collected, and also new sprouts for 5 trees in Tiva PTS were collected. The branches were adjusted to scions by CPs in

the laboratory of Kitui centre. The CPs have already taken the cutting skill, which consists of preparation of study, collection of appropriate scions, adjusting and so on. It is confirmed that the skill of technical staff of KEFRI has been improved gradually as well as KEFRI researchers.

The scions were adjusted to 50cm length with 2 to 3 leaves, and then soaked in running water one night to recover the vitalities. The recovery was better than the cutting study conducted on Apr.

Instead of seedling plastic bags, long plastic pots carried from Japan were introduced for cutting pots. A small greenhouse was newly constructed with plastic sheet cover in the nursery to put the cutting pots. The greenhouse was covered with shade net to avoid high temperature inside. Watering at morning, evening and several times on daytime to keep appropriate temperature, less than 40 degree inside was confirmed.

2.2 Melia seed orchard in Tiva

Weeding of the seed orchard has not been carried out, and much shrubs and bushes have grown thick under the canopies of Melia. This may cause the decline of efficient fruits collection, so Mr. Luvanda, the new director of Kitui centre, requests KEFRI HQs to purchase bush cutters with engine to reduce the maintenance cost of the orchard. FTBC also explained that weeding time should be considered for carrying out it efficiently.

2.3 Acacia seed stand/PTS

The growth of Acacia planted Dec. 2015 is much better than that planted Apr. 2016 through one growing period of rainy season on Dec. It was found that the growth was different from planted areas, and it may be caused by soil condition because inferior trees have grown in specific area rather than the family. Superior Acacia can grow with DBH:8cm and Height :4m, and the stem can grow up straightly. It is necessary to consider when and how the thinning will be carried out.

3. Meeting with KEFRI/CPs

I explained the details of study on Melia cutting in Kitui to Dr. Muturi and Mr. Kariuki. I also explained the study on Japanese Melia cutting in FTBC, which succeeded with rooting through using Kanuma soil. I requested them to seek the same kind of soil for Kanuma, which has slightly acidity. Dr. Muturi mentioned that formation of callus and no rooting on Melia cutting study has been reported, and this study could be reported to a journal concerned if it will be successful.

Concerning KEFRI budget for maintenance of Melia seed orchard, CADEP project budget from national treasury of Kenya has not been disperse to KEFRI, so CPs bear travel allowance by themselves. Dr. Muturi expressed that KEFRI could prepare the maintenance budget on the next Japanese fiscal year 2019.

4. Meeting with Japanese experts

Mr. Takahata, Chief advisor of CADEP, explained that KEFRI would be responsible to disperse monthly labor fees for maintenance of sites from next Japanese fiscal year due to a request

from JICA Kenya office. An officer in charge of accountant in JICA Kenya office will explain the change to KEFRI. So far, a CP has taken monitoring of all sites including PTSs while dispersing the labor fees in the sites. The monitoring of all sites should be continued to check the situation of the sites, which includes unordinary growth, pest and disease, soil condition and so on.

Concerning a required term of tree breeding on Melia, I explained that a half of logging term, which means 7 – 8 years on Melia, or 15 years until harvesting as possible, should be prepared for selecting superior clones exactly by PTS assessment, according to a question from Mr. Saito, an expert of forestry extension. I mentioned that FTBC can take technical supports for establishment of Melia local seed orchards that are planned by private sectors such as KOMAZA.

5. Subjects

- Assignment of Director General KEFRI and exchange of director of Kitui regional centre

  Director General of KEFRI has not been assigned and Dr. Jane Njugura has been an acting DG. Dr. Ndufa moved to KEFRI HQs from Director of Kitui regional centre, and Mr. Luvanda was assigned as a new DG of Kitui centre. He arranged properly attendance of CPs concerned for the field study for Melia cutting.

- Mid-term review of CADEP project

  FTBC will dispatch 2 short term experts for mid-term review of CADEP project, which is planned on middle of Feb. 2019, to discuss with JICA mission member, CPs and experts on the review of project activities and so on.

6. Contact persons

Dr. Muturi, Manager of Component 4, KEFRI
Mr. Kariuki, Tree breeding researcher, KEFRI
Mr. Luvanda, Director, KEFRI Kitui regional station
Mr. Auka, Staff, KEFRI Kitui regional station
Mr. Kyalo, Staff, KEFRI Kitui regional station
Ms. Floza, Staff, KEFRI Kitui regional station
Mr. Keiichi Takahata, Chief Advisor, CADEP
Mr. Katsuro Saito, Forestry Extension, CADEP
Ms. Yuki Honjyo, Regional Cooperation/Coordinator, CADEP

Photo

Photo 1 Collection of scions from new branch in Melia seed orchard

Photo 2 Collection of scions from new flash in Melia PTS

Photo 3 Adjusting scions for cutting by CP

Phot 4 Scions after adjusting for cutting (wilted leaves)

Photo 5 Scions soaking in running water for 1 night (leaves of scions recovered)

Photo 6 Cutting measure

Photo 7 Watering to cutting pots

Photo 8 Small greenhouse covered with plastic sheet and shade net

Photo 9 Inside of greenhouse covered with plastic sheet and shade net

Photo 10 Melia seed orchard (Low understory vegetation, Tiva)

Photo 11 Melia seed orchard (Low understory vegetation, Tiva)

Photo 12 Acacia seed stand (Left: planted Dec. 2015, Right; planted Apr. 2016, Tiva）

Attachment

Study on effect of origin of scion for Melia cutting

Three(3) kinds of scions will be collected from seed orchard and progeny test site.

1. New branch in Seed orchard

3. New buds from ground or stem in progeny test site

Study plan for cutting of Melia

	2018		2019											
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Collect scions	◆					⟷	⟷						⟷	
		# take photos every week												
Check the scions				⟷				⟷						⟷
Attendance of FTBC	⟷			⟷			⟷						⟷	

Tentative study plan for grafting of Acacia

Acacia	⟷ sowing to make rootstocks												⟷ grafting	

Study on cutting of Japanese Melia in FTBC (Aug. 2018)

Cutting of Japanese Melia in pots using nursery black soil

(new buds were collected from stumps as scions)

30 % of scions can get rooting (after 1 month)

90% of scions can get rooting in pot using special soil (after 1 month)

Appendix 5-1-5

Project Management

Field	Name	Term
Project Management	Dr. Masatoshi Ubukata	13 - 24 Feb 2019
Project Management	Mr. Shizuo Kamizore	13 - 24 Feb 2019

1. Schedule

Date		Contents	Stay
13 Feb. (Wed.)		Move (Hitachi – Haneda)	
14 Feb. (Thu.)		Move (Haneda – Doha – Nairobi)	Nairobi
15 Feb. (Fri.)	AM PM	Documentation Meeting with experts	Nairobi
16 Feb. (Sat.)	AM PM	Documentation Meeting with JICA team and experts (Dr. Ubukata arrived)	Nairobi
17 Feb. (Sun.)		Documentation	Nairobi
18 Feb. (Mon.)	AM PM	Meeting with JICA team, Discussion with CP and JICA team (KEFRI) Meeting with CP (KEFRI)	Nairobi
19 Feb. (Tue.)	AM PM	Meeting with JICA team Documentation	Nairobi
20 Feb. (Wed.)	AM PM	Review discussion with JICA and Kenyan review team Meeting with KOMAZA	Nairobi
21 Feb. (Thu.)	AM PM	Joint Coordinating Committee (JCC) Move to Kitui	Kitui
22 Feb. (Fri.)		Investigation of Melia seed orchard, Melia PTS, and Acacia seed stand, Melia cutting study Move to Nairobi airport, move (Nairobi – Doha)	
23 Feb. (Sat.)		Move (Doha – Haneda)	Haneda
24 Feb. (Sun.)		Move (Haneda – Hitachi)	

2. Results of major activities

2.1 Midterm review of the project

- Discussion on evaluation of component 4 with JICA team

Discussion on activities of component 4 and midterm review of the achievement was held with JICA team, Dr. Muanza as a KEFRI reviewer, CPs concerned and Japanese experts in KEFRI.

Dr. Muturi, component manager, explained the results of tree breeding activities in CADEP, which were composed of selection of superior clones based on PTS assessment, acquiring data analysis technique, fruit production by artificial crossing and management of Acacia seed stand and so on. The activities and achievement so far were highly evaluated by the review team. Dr. Muturi also explained that project budget to KEFRI would be distributed from the national treasury, and income from selling improved Melia seeds would be allocated for the maintenance of the seed orchards and PTSs.

- Meeting with CPs in KEFRI

A meeting with CPs, Dr. Muturi. Dr. Ndufa and Mr. Kariuki, was held in KEFRI. Personal transfer of CPs was talked about, and it was confirmed that this matter would have a risk to achieve the project purpose and would be mentioned to the review team.

- Discussion on a report of midterm review

Discussion on a report of midterm review was held among all member concerned in Ministry of Environment and Forestry. Few particular opinions were expressed to the report.

2.2 Joint Coordinating Committee (JCC) meeting

4th JCC meeting was held in the Ministry chaired by Mr. Gathaara, Conservation Secretary of the Ministry, with the participation of Kenyan reviewers, JICA team, CPs concerned, a secretary of Japanese embassy, a deputy representative of JICA Kenya office and Japanese experts.

JICA team explained the outline of review report. Concerning component 4 in the report, the following achievements were evaluated; selection of superior Melia trees, fruits production by Melia artificial crossing and strengthening research ability for basic statistical data analysis, cutting techniques, pollen collection and artificial pollinating technique. On challenges in the report, serious risks of CPs transfers in the project duration, recruit of young researches for tree breeding and preparation of budget for maintenance of seed orchard and PTSs for the sustainable management. On recommendations, allocation of income by selling Melia for maintaining seed orchards and PTs was described.

Then, activities and achievements of all component were presented from each component manager. Dr. Muturi presented the outline.

2.3 Observation of Melia seed orchard in Tiva

We observed Melia seed orchard in Tiva. Much bushes and weeds were found inside, because weeding had been suspended from last year. Introduction of bush cutters with engine for weeding is considered, and 2 times of weeding a year must be needed to keep suitable condition of seed orchard.

2.4 Observation of Melia PTS in Tiva

The growth of Melia trees in PTS was going well with DBH:12 – 14cm, height:8m. it was found that the height growth would become moderate and the diameter growth is advancing gradually. Weeds on the ground was a few due to a regular weeding for assessment.

2.5 Observation of Acacia seed stand/PTS

Acacia trees with superior growth in seed stand was growing to DBH:10cm and height:6m, and the stem of tree was standing straightly. The growth of Acacia is much better than expected, so

thinning should be considered for appropriate management.

2.6 Study on Melia cutting

No formulation of callus and rooting in all scions were found in Melia cutting experiment conducted in Nov. 2018. Scions from new sprout, which could succeed in rooting 3 years ago, were used for cutting this time, however, no rooting on the scions was found. It is considered that higher temperature more than 50-dergree, which was confirmed on a thermometer installed in the greenhouse, was one of the causes for no rooting. The condition of scions had been recovered vigorously after soaking running water for one night as well as that of Japanese Melia in cutting study, and the scions was not considered as the cause. Control of cutting bed condition should be examined to keep suitable temperature and moisture for cutting.

3. Subjects

- Diffusion in the achievements of tree breeding activities

  The achievements of tree breeding activities on CADEP are highly evaluated, and diffusion in the information, especially in Japan, is required from JICA team through indicating numerical results. Increase of growth on Melia as the result of breeding, for example, can be presented from the data analysis of PTS assessment on a trait table of the Melia plus trees.

- Meeting with KOMAZA

  It was confirmed that KOMAZA had a plan to establish a local Melia seed orchard in a meeting with Mr. Kumahira, senior manager of KOMAZA. A MoU between KEFRI and KOMAZA has been under consideration to proceed cooperation with a private sector for extension of improved Melia. FTBC takes technical supports such as selection of suitable clones and design of a seed orchard through KEFRI to establish a Melia clonal seed orchard.

4. Contact persons

Mr. Gathaara, Conservation Secretary, Ministry of Environment and Forestry
Dr. Cheboibo, Deputy director, KEFRI
Dr. Muturi, Component manager, KEFRI
Dr. Ndufa, Senior researcher, KEFRI
Mr. Kariuki, Tree breeding, KEFRI
Mr. Paul, Tree Breeding, KEFRI
Ms. Floza, Technical officer, Kitui regional centre of KEFRI
Mr. Tomonobu Kumahira, Senior manager, KOMAZA
Ms. Yui Takashima, Secretary, Embassy of Japan in Kenya
Mr. Keiji Yamazaki, Executive technical advisor, Global environment department, JICA
Ms. Mari Miura, Senior deputy director, Global environment department, JICA
Mr. Shinjirou Amameishi, Deputy representative, JICA Kenya office
Ms. Yoko Okonogi, Project formulation advisor, JICA Kenya Office
Mr. Keiichi Takahata, Chief Advisor, CADEP
Mr. Katsuro Saito, Forestry Extension, CADEP

Photo

Ms. Yuki Honjyo, Regional Cooperation/Coordinator, CADEP

Photo 1 Meeting in Ministry of environment and forestry

Photo 2 JCC Meeting in the Ministry (chaired by Mr. Gathaara, conservation secretary of the Ministry

Photo 3 Melia seed orchard in Tiva

Photo 4 Melia PTS (planted Dec. 2015)

Photo 5 Acacia seed stand/PTS (planted Dec. 2015)

Photo 6 Study on Melia cutting (conducted on Nov. 2018)

Appendix5-1-5-1

Joint Mid-Term Review Report
on Kenya-JICA Capacity Development Project for Sustainable Forest Management
(2016-2021)

21 February 2019
Joint Mid-Term Review Team

JICA Mission headed by Mr. Takashi Yamazaki of Global Environment Department in Tokyo, Mr. Hiroshi Nakata and Ms. Mari Miura, together with the reviewers from the Government of Kenya (GoK); Mr. John Orela, Ministry of Environment and Forestry (MOEF), Mr. Mathenge Gitonga, Kenya Forest Service (KFS), and Mr. Ely Mwanza, Kenya Forestry Research Institute (KEFRI) conducted Joint Mid-Term Review on "Capacity Development Project for Sustainable Forest Management (CADEP: 2016-2021)" from 14 -21 February 2019 in Nairobi, Kenya. They will present this report at Joint Coordination Committee (JCC) to be held on 21 February 2019.

1. Overview of the past Kenya-JICA's cooperation in forestry sector and the current CADEP project

In 1985, the Government of Japan (GoJ) started its cooperation to GoK to support Kenyan's efforts of social economic development through the forestry sector. The first cooperation was a grant aid to build KEFRI headquarters and JICA's technical cooperation to support social forestry nursery to respond the GoK's policy implementation to address the shortage of wood-based energy sources. Since then to 2015, the cooperation between GoK and GoJ have been in the field of; 1) establishment of the Center of Excellence of forest research and development and its extension, KEFRI, 2) development of social forestry and its extension model, and 3) tree breeding for drought tolerance for building climate change resilience. The uniqueness of Kenya-Japan's cooperation is that it is not limited in bilateral cooperation but extended to regional cooperation, starting from the third country training programs since 1995 and being led to formulate the "African Initiative for Combating Desertification (AI-CD)" in 2016.

GoK has made significant progress of forestry development until today. They now set an ambitious target to achieve 10% forestry tree cover under the constitution originally by 2030 and now moved forward to 2022, and to achieve 30% GHG reduction compared to business as usual base by 2030 as their Nationally Determined Contribution (NDC). Kenya also has met new development challenges, which include decentralization since 2013, rising needs for further cooperation with multi-stakeholders such as the private sector and NGOs/CBOs, and global issues such as climate change, drought, and desertification. GoK, with supports from JICA, started CADEP from 2016 to address these challenges and to secure further sustainability of the past cooperation, which is expected to

contribute for Kenya to achieve sustainable development. Two and half years have passed so far and it is now the time for a mid-term review to confirm the progress made so far and identify challenges and its solutions towards the latter half of the project implementation.

2. The result of review

2-1. Policy Support (Component 1)

2-1-1. Overview

Policy implementation process towards the 10% target has been further advanced at national level, yet the review of activities for the latter half of the project is required following the changing situations

Component 1 aims to strengthen policy implementation process at national level mainly through the National Forest Programme (NFP) for achieving the 10% target.

2-1-2. Achievements and further steps

The project made a summary of forest-related policies and strategies. The project drafted NFP Action Plan through participatory workshops in three (3) areas, namely, Nairobi, Mombasa and Eldoret in February and March 2018. The project will update the NFP Action Plan with more detailed budget information and validate it at a workshop to be held in March 2019.

Draft NFP Action Plan

NFP Action Plan Workshop

2-1-3. Challenges

The NFP process has delayed due to unexpected situations such as keeping on hold of the new Finnish corporation to NFP. For instance, the NFP board to implement NFP has not been established yet. MOEF and key agencies need to accelerate its activities as President gave a directive in 2018 to move the target year to achieve 10% forest cover from 2030 to 2022.

During the review, MOEF represented by Conservation Secretary pointed out that they need to revise the Forest Policy and amend the Forest Conservation and Management Act, 2016, and update the

NFP both in 2019. They also said that Component 1 to implement the review of the Forest Conservation and Management Act, 2016 and the Draft National Forest Policy, 2015 based on recommendations of the task force.

2-1-4. Recommendations from the Review Team

(1) To prioritize what activities should be implemented under Component 1 considering allocated resources of both GoK and JICA and recognizing that GoK has started the process of revisions of Forest Conservation and Management Act, 2016 and Draft National Forest Policy, 2015. As long as the Review Team see the current situation, the revision of Forest Conservation and Management Act, 2016 would be more priority than the NFP revision in 2019.

(2) To strengthen activity 1-5; "prepare policy briefs based on project field activities utilizing NFMS" to be implemented in the final year, by revising it to "release policy briefs based on activities on forestry extension at county level (Comp. 2), REDD+ (Comp. 3), tree breeding (Comp. 4) and regional cooperation (Comp. 5)" in the latter half of the project. These policy briefs would enable GOK to share outcomes and lessons from the project implementation to wider stakeholders in Kenya, Africa and even further. The Review Team also recommends Chief Advisor and JICA Experts to feed Japan's knowledge and experiences including challenges and its solution in forestry into its policy briefs.

(3) Support counties understand the issues of forest policies by sharing documents such as NFP (already shared to pilot counties), Draft Forestry Law and Forest Conservation and Management Act, 2016.

2-2. Forestry extension in pilot counties (Component 2)

2-2-1. Overview

Sustainable Forest Management (SFM) process has been advanced at pilot Counties. However, the reconstruction of the project design is required due to the delay of decentralization process.

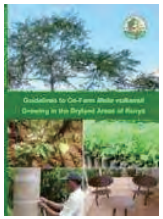
The Component 2 aims at capacity development of pilot counties; Embu and Taita Taveta to enhance devolution and promote SFM to contribute to the 10% target in cooperation with multi-stakeholders such as the private sector and NGOs/CBOs.

2-2-2. Main achievements and further steps

Participatory Forest Management Plans (PFMPs) are being developed for three (3) forests, namely, Kiang'ombe and Kianjiru in Embu, and Mwambo in Taita Taveta. PFMP of Kiang'ombe Hill (2018-2022) was approved by Chief Conservator of Forests of KFS on 21 December 2018. Embu County Government and the Kiang'ombe Hill Forest Conservers Association are expected to sign the Forest Management Agreement soon, which will be the first case of such agreement between a county government and a community forest association (CFA) in Kenya. The same processes will be followed by the stakeholders of other two forests.

Farmers Field Schools (FFSs), selected as an extension approach with community participation, are organized in 35 groups with 700 participants to promote tree growing and farmers' learning. KFS sees that FFS is a good tool to build trust between governments and communities, and encourage farmers including women to participate in sustainable forest management.

Efforts to promote improved Melia growing in the pilot counties and beyond have been made. KEFRI, KFS, and a private company; Better Globe Forestry Ltd., jointly developed "Guidelines to On-Farm *Melia volkensii* Growing in the Dryland Areas of Kenya". The Project held promotion seminars of Melia in Nairobi, Embu, and Voi, where 120 participants attended. KFS and KEFRI have started cooperation with the private sector such as Komaza and local farmers to grow improved *Melia volkensii*.

		
Practice to draft PFMP	Melia Guidelines	Awarding of FFS certificate

2.2.3 Challenges

One of the major targets of the Component 2 is to develop the capacity of the pilot county governments to enhance devolution process of the forestry sector. However, officers in charge of forestry (foresters) have not yet been recruited by the pilot counties, which caused a considerable delay in the capacity development processes. Therefore, the Project is required to review its design to slightly shift its emphasis and resources from the capacity development of the pilot county governments to that of the other stakeholders of tree growing in ASALs. Yet, as the Project still recognizes the importance of the capacity development of county governments, it will keep on requesting the pilot counties to recruit foresters. Revised plan of the Component 2 will also include formulation of strategies to promote tree growing in ASALs.

Distribution channel of improved Melia seeds/seedlings is currently limited only at KEFRI (Kitui and Muguga), which hampers the promotion of improved Melia growing. Therefore, the Project needs to seek ways to increase and improve distribution channels for end users. The Project, with supports from JICA Experts on tree breeding, also needs to consider supporting the private sector who intends to establish seed orchards of improved Melia.

2-2-4 Recommendations from the Review Team

(1) To further strengthen collaboration among KFS, the pilot county governments, the private sector, NGOs/CBOs, and KEFRI / Component 4 to promote improved Malia glowing.

(2) To compile achievements and lessons gained through pilot activities in Embu and Taita Taveta, which can be referred to by other counties.

2-3. REDD+ Readiness (Component 3)

2-3-1. Overview

REDD+ readiness phase has advanced through the developments of NFMS and FRL, and further actions to strengthen them are required to meet UNFCCC requirements

The Component 3 aims to promote REDD+ readiness phase by developing National Forest Monitoring System (NFMS) and Forest Reference Level (FRL: future GHG emissions/removals projection without REDD+ implementation), which meet two out of four of UNFCCC requirements for REDD+ Result-based Payment. GoK sees REDD+ an opportunity to promote sustainable forest monitoring in addition to reduce GHG emissions and to access climate finance.

The NFMS in Kenya is defined as a comprehensive package which is composed of; 1) a database hardware for monitoring and reporting (and this is named as "Forest Information Platform (FIP)) and 2) forest monitoring methodologies in Kenya.

2-3-2. Main achievements and further steps

The Forest Information Platform (FIP) as a database, with data management functions of NFMS to manage forest resources data, was designed and established. The FIP has been operated since July 2018. **National forest monitoring methodologies** to monitor policy implementation, GHG emission/removal, biodiversity etc. are on the process of its development and documentation as a draft NFMS document. The project will strengthen FIP technically and finalize the NFMS document in the latter half period of the project.

The first FRL report was developed originally with the aim to be submitted to UNFCCC by January 2018, and then by January 2019. GoK however decided to submit it by January 2020 after completing responses to technical comments made so far by peer reviewers.

GoK expects to complete the National REDD+ Strategy, which is supported by the FCPF readiness project, on October 2020. They seek more diverse financial channels not limited to public finance such as that of GoK's and Green Climate Fund (GCF) but also the private finance.

Design of NFMS

Image of FIP

Ground Survey

2-3-3. Challenges

FRL needs to be passed technical assessment of UNFCCC. Submission of FRL after January 2020 and technical challenges such as measuring forest degradation would require GoK more resources for FRL development. FIP needs to be robust enough for universal-use and being user-friendly for wider stakeholders. Maintenance costs for equipment forming FIP such as the server and software licenses are required.

2-3-4. Recommendations from Review Team

(1) To make the FIP further operational and sustainable by making necessary institutional arrangement (e.g. staffing, budgeting) and strengthening and making the FIP more user-friendly by reflecting the needs of wider stakeholders (e.g. other government agencies, NGOs/CBOs, and private companies).

(2) To review and modify the Plan of Operation (PO) in accordance with the change of the schedule of FRL submission from 2019 to 2020. REDD+ process including FRL development is associated with uncertainty and external factors such as UNFCCC technical assessments and international negotiations and discussions. Therefore, KFS and JICA Experts are requested to adjust project activities efficiently and flexibly to utilize limited allocation of JICA experts of Component 3.

(3) To secure maintenance cost for equipment.

2-4. Tree Breeding (Component 4)

2-4-1. Overview

Great progress on Melia and Acacia breeding has been made and it would make Kenya resilient to climate change. Further institutional arrangements for securing sustainability is required.

Component 4 aims to improve drought tolerant trees in arid and semi-arid area, namely *Melia volkensii* and *Acacia tortilis*, which are the first experiment in Africa regarding native species. Melia has potentials to be grown not only in Kenya but also in East Africa, and *Acacia tortilis* has potentials even in entire Africa.

2-4-2. Main achievements and future steps

KEFRI has developed improved *Melia volkensii* and *Acacia tortilis* seeds following the past technical cooperation "Development of Drought Tolerance Trees for Adaptation to Climate Change in Drylands (2012-2017)". Both breeding show significant progress on its improvement so far.

As for Melia, good trees have been selected that show at present more than 17% timber volume increase. KEFRI has also succeeded in fruits production by a basic artificial pollinating method used for fruit trees. As for Acacia, the growth more than expected have been confirmed in three (3) time growth assessments. Capacity of KEFRI's researchers have been strengthened in the field of basic statistical analysis, cutting, collection of pollen, artificial crossing operation and many others. The project will further experiment to improve Melia/Acacia seeds.

Artificial crossing	Progeny test sites

2-4-3. Challenges

The Project has faced the challenge of transfers of key researchers/staff who are engaged in the project activities. Such transfers could be serious risks for the implementation of activities under Component 4 in the latter half project duration. More researchers, particularly those of young generations, are needed for promoting breeding more effectively and efficiently.

Budgeting for maintaining seed orchards and progeny test sites by KEFRI is required. During the discussions with the Review Team, Acting Director of KEFRI pointed out that they need to internalize its budget into their ordinal budget rather than to allocate project counterpart budget in order to secure sustainability.

2-4-4. Others

KEFRI shared with the Review Team National Tree Improvement Strategy (2018-2043) and National Seed Production, Certification and Distribution Strategy (2018-2043), and explained the previous KEFRI-JICA cooperation of tree breeding is a trigger to develop these strategies. These are quite positive progress for KEFRI and GOK to institutionalize and strategize breeding to achieve the 10% forest cover target and further development objectives.

2-4-5. Recommendations from the Review Team

(1) To maintain robust personnel allocation to the project activities in the latter half project duration for making sure to achieve the project purpose, and also to hire young researchers for tree breeding because tree breeding requires long-term investments and skilled researchers/technicians.

(2) To internalize budget to maintain seed orchards and progeny test sites into their ordinal budget as intended by Acting Director of KEFRI. To consider strategic allocation of income by selling Melia for maintaining seed orchards and progeny test sites.

2-5. Regional Cooperation (Component 5)

2-5-1. Overview

Kenya is leading the Horn of Africa as regional-hub to fight desertification and further strategic activities to make impacts on the ground are needed.

Kenya is leading the African Initiative for Combating Desertification (AI-CD) with Senegal (Sahel-hub) supported by JICA and UNCCD. KEFRI is promoting 1) networking, 2) knowledge-sharing, and 3) access to finance in the Horn of Africa under the activities of Component 5.

2-5-2. Main achievements and further steps

AI-CD has been promoted with Kenya's strong political commitments and leaderships since its formulation during TICAD VI in Nairobi in 2016. AI-CD Ministerial Meeting for Horn of Africa was hosted by MOEF with support from JICA in Nairobi in June 2017. Two (2) AI-CD regional forums for the Horn of Africa were held with the participation of AI-CD focal points.

Knowledge Management System has been established on the KEFRI website for member countries to collect and store good practices and make it available to wider stakeholders. Two (2) regional workshops and two (2) country trainings have been conducted so far by KEFRI to support stakeholders in Kenya and HoA countries to collect good practices and share them with relevant stakeholders to be used on the ground. Regional trainings included trainings to access to finance.

The project will continue activities to promote knowledge-sharing and to improve access to finance in Kenya and the region and strengthen capacities of stakeholders in the latter half duration of the project. AI-CD is planning to hold a side event at TICAD VII (August 2019 in Yokohama, Japan) and/or UNCCD COP14 (October 2019 in India) and presenting the achievements so far, which include those made under the CADEP Component 5.

AI-CD Ministerial Meeting

Training

CADEP website for knowledge sharing

2-5-3. Challenges

Good practices have not been collected as many as expected especially from other Horn of Africa Countries. Further strategic promotion of knowledge-sharing and technology transfer in Kenya and the region are to be considered to make impacts on the ground.

Member countries have faced the lack of finance. Even though participants of these trainings want to collect good practices and distribute them to target stakeholders such as farmers in their home countries, they do not have adequate finance. The same is happening when participating stakeholders write good concept notes of new projects, but are not able to find finance sources. KEFRI has been advising member countries to seek opportunities by accessing finance mechanisms, donors and others in their countries. At the same time, KEFRI is requesting JICA to continue seeking available funds including those of other partners' to collect good practices on the ground and to hold consultation meetings for writing proposals of new project to be submitted to funding mechanisms.

2-5-4. Recommendation from the Review Team

(1) To take opportunities of regional meetings and trainings by requesting participants to bring and present good practices, then store them into Knowledge Management System.
(2) To consider packaging good practices collected so far in the form of guidelines or handbooks and upload them on the web in order to make them further available for wider stakeholders. Possible side events at TICAD VII and/or UNCCD COP14 would be other opportunities to share such outcomes.
(3) To institutionalize collecting and sharing good practices into their ordinal works for securing sustainability.
(4) (To JICA HQs / AI-CD Secretariat) To continue seeking available funds, as seed money to support member countries to collect good practices and to hold consultation meetings to formulate good proposals. Funding from JICA and other multilateral funding mechanisms including Japan as a major contributor, the private sector and any other agencies.

2-6. Overall project implementation issue

MoEF explained that the counterpart budget of 2018/2019 has already been disbursed to KFS and KEFRI as per last week's directive.

2-7. Recommendation towards achieving overall goal and further

(1) To incorporate programs to extend and scale-up the field activities implemented under the CADEP to a revised NFP and the NRS. These include extending activities in forestry extension in two pilot counties to nationwide and to implement tree breeding of major species in addition to *Melia volkensii* and *Acacia tortilis*.
(2) To develop a road map of strategic implementation of participatory forest management plan nationwide. This would include to identify how many community forests exist in Kenya , how many of them require PFMP, which community forests are prioritized, its timeline, and how the PFMPs implementation in all counties are internalized in national policies and programs.
(3) Current deforestation-based estimates of Kenya may indicate possible relatively small GHG emission reduction potentials. However, REDD+ is an opportunity for GoK for climate change mitigation and sustainable forest management. Nevertheless, the diversification of finance resources is a key for GoK where major areas are drylands. Therefore, seeking adaptation funds more would increase opportunities to GoK. This would be realized by including adaptation components into the National REDD+ Strategy.
(4) To seek further accessing GCF adaptation fund based on breeding-related strategies that KEFRI formulated in 2018 and outcomes from Component 4. Drought tolerance species such as improved Melia and Acacia are promising to promote adaptation measures in ASALs in Kenya.
(5) To seek development and climate finance for supporting Kenya and member countries to collect and distribute good practices and to develop fundable proposals to fight desertification.

3. Review by Indicators

There are no significant delays of activities nor hampering factors that could negatively affect in achieving indicators set for the project.

END

(Photos in this report are from CADEP website/presentations)

Appendix 5-1-5-2

Ministry of Environment and Forestry

KENYA Forest Service

JICA

The 4th Joint Coordinating Committee Meeting of Capacity Development Project for Sustainable Forest Management (CADEP-SFM)

1. **Date:** 21s February 2019
2. **Time:** 9.00. am
3. **Venue:** 15th floor Water Towers Boardroom, NHIF Building, Ministry of Environment and Forestry (MoEF)
4. **Agenda**

Time	Item
8:30-	Registration
9:00-	Welcome remarks from the Chair
9:10-	Remarks by JICA
9:20-	Presentation by the Joint Mid-term Review team
9:40-	Discussions
10:00-	Tea break
10:20-	Achievement and progress (June 2016 – December 2018) and proposed revision of PO and PDM (1) Component 1: Mr. Gordon Sigu (Component 1 Focal Point) (2) Component 2: Mr. Peter N. Nduati (Component 2 Manager) (3) Component 3: Mr. Peter N. Nduati (Component 3 Manager) (4) Component 4: Dr. Gabriel Muturi (Component 4 Manager) (5) Component 5: Dr. Ebby Chagala-Odera (Component 5 Manager), (6) Proposed revision of PDM (Overall Goal and Project Purpose); Mr. Keiichi Takahata (Chief Advisor)
11:20-	Discussions
11:40-	Way forward
11:50	Closing remarks by the Chair
12:00 -	Lunch

List of 4th Joint Coordinating Committee (JCC) Members
Ministry of Environment and Natural Resources
21st February 2019

CADEP-SFM

No.	Position	Name	Remarks
1	Principal Secretary	Ali Noor Ismail	
2	Conservation Secretary, MoEF	Gideon N. Gathaara	
3	Director, KFS	Monica Kalenda	
4	Director, KEFRI	Jane Njuguna	
5	Representative from National Treasury	Robert Gatonga	Deputy Head, Asia Pacific Division in Resource Mobilisation Department
6	Representative from Ministry of Devolution and Planning	Monicah N. Kinuthia	Ag. Director: Natural Resources, Environmental Management, Livestock Dev. & Food Security
7	Representative from County Executive Committee for Environment	David Ngeno	Chair of County Executive Committee on Environment
8	C.E.C.M in charge of Water, Irrigation, Environment and Natural Resources in Embu County Government	Patrick Waganagwa	
9	C.E.C.M in charge of Lands, Environment and Natural Resources, Taita Taveta County Government	Getrude Shuler	
11	MoEF	John Orela	Mid-term reviewer
12	KFS	Mathenge Gitonga	Mid-term reviewer
13	KEFRI	Elly Mwanza	Mid-term reviewer
14	Principal Research Scientist, KEFRI	Gordon Sigu	Component 1 Focal Point
15	Deputy Assistant Chief Conservator of Forests, Climate change Response Programme, KFS	Alfred N. Gichu	
16	Component 2 & 3 manager	Peter N. Nduati	Component 2 & 3 Manager
17	Deputy Director, Biodiversity and Environment Management, KEFRI	Gabriel Muturi	Component 4 Manager
18	Regional Director, KEFRI Kitui DERP	Albert Luvanda	
19	Deputy Director, Technical Support Service, KEFRI	Ebby Chagala-Odera	Component 5 Manager
20	JICA Kenya Office	Keiko Sano	Chief Representative
21	JICA Kenya Office	Shinjiro Amameishi	Senior Representative
22	JICA Kenya Office	Yoko Okonogi	Project Formulation Advisor
23	JICA Kenya Office	John N. Ngugi	Senior Programme Officer
24	JICA Headquarters	Takashi Yamazaki	Executive Technical Advisor to the Director General
25	JICA Headquarters	Mari Miuri	Senior Deputy Director
26	Embassy of Japan	Yui Takashima	Second Secretary, Ecoomic Cooperation Section
27	Chief Advisor/Forest Policy	Keiichi Takahata	CADEP-SFM
28	Deputy Chief Advisor/ Forestry Extension	Katsuro Saito	CADEP-SFM
29	Regional Cooperation/Coordinator	Yuki Honjo	CADEP-SFM
30	REDD+ Readiness	Kazuhisa Kato	CADEP-SFM
31	Tree Breeding	Masatoshi Ubukata	CADEP-SFM
32	Tree Breeding	Shizuo Kamizore	CADEP-SFM

Appendix 5-1-5-3

CADEP SFM Component 4 (Tree Breeding) Component

Progress report Presented to 4th JCC meeting Held on 21st February 2019

Dr. Gabriel M. Muturi, Mr. Jason Kariuki - (KEFRI),
&
Dr. Ubukata and Mr. Kamizore – FTBC

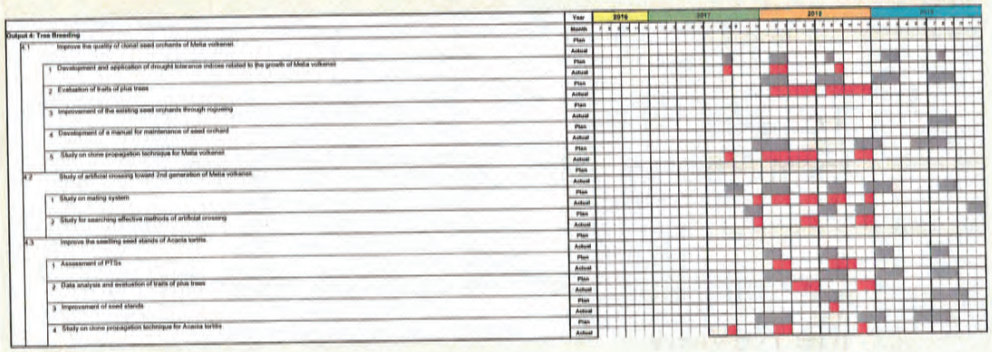
Component 4: Tree Breeding

- Provide technical advice to Component 2 for ensuring legal requirements and control of the improved seed/seedlings as well as designing seed orchard of *Melia volkensii* for considering partnership with County Governments and private sector for dissemination
- Draft a plan for cost-sharing between KEFRI and JICA for efficient management of seed orchards and progeny test sites of *Melia volkensii* and seedling seed stands of *Acacia tortilis* based on available budget of KEFRI
- Consider an exit plan after end of project toward 2nd generation of *Melia volkensii* before the end of the Project

Purpose of the Mission

- To review the progress before Mid-term Review planned early next year
- To make suggestions to the Project for the Review

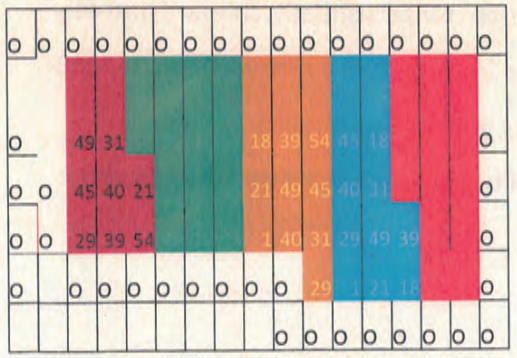
Activities of Compo. 4 Tree Breeding 2018/19 FY



4.1 Improve the quality of clonal seed orchards of Melia volkensii

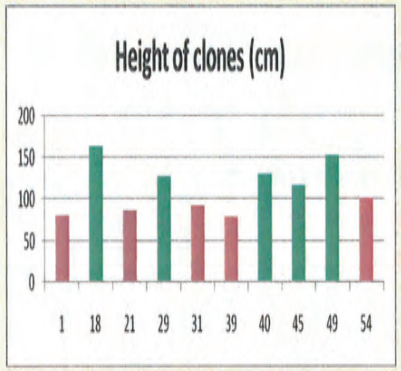
- Development and application of drought tolerance indices related to the growth of *Melia volkensii*
- Evaluation of traits of plus trees
- Improvement of the existing seed orchards through rogueing (deferred)
- Development of a manual for maintenance of seed orchard (Not Yet)
- Study on clone propagation technique for Melia volkensii (Not yet)

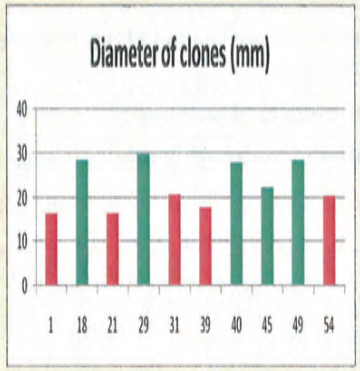
Development and application of drought tolerance indices related to the growth of Melia volkensii



- Controlled experiment established at Tiva to compare drought tolerance traits between fast and slow growing Melia CPTs
- Fast Growing CPTs: 18,29,40,45,49
- Slow growing CPTs: 1,21,31,39,54
- Gas exchange
- Growth: Height &DBH

Growth trends consistent with that observed from the orchards





Evaluation of traits of plus trees

- Assessment of Progeny tests– twice annually, January and July
- Last assessment was done in Sept 2018 a delay from July 2018
- January 2019 assessments not yet undertaken
- Potential risk in data quality and low return on investments

4.2: Study artificial crossing of Melia volkensii for developing second generation

- *Mating system studies have not yet been started*
- Artificial crossing of selected best Melia families ongoing but also on a small scale
- Monitoring of fruits of artificial crosses made in June 2018
- No activity so far in 2019/20

Artificial crossing of Melia

Results for Artificial crossing of Melia

Melia flowers

Pollen collection

Pollen processing and storage

Artificial Pollination

Artificial Pollination

Artificial Pollination

Fruits from artificially crossed flowers

Early fruiting

3 months fruits

Crosses will be verified using molecular techniques

4.3:Improve seedling seed stands of Acacia tortilis

- **Assessment of progeny tests/seed stands– twice annually, January and July**
- Data analysis and Evaluation of PTS – To support further improvement /selection
- Improvement of seed stands through thinning -Using results of Data analysis Yr4- Oct 2018 and of January 2019 assessment
- Study on clone propagation technique for *Acacia tortilis*
- ***Last assessment was done in October/November 2018 a delay from July 2018***
- ***January 2019 assessment not yet undertaken***
- ***Potential risk in data quality and low return on investments***

Melia Seed Orchards Management

- Orchard sites weedy and in poor condition
- Require urgent weeding as they were last weeded in November 2017
- We are considering undertaking mechanized bush clearing

Assessment of Acacia seed stand/progeny test

- Growth data collected in both Kibwezi and Tiva
- Seeding observed in some trees

Management of Acacia tortilis seedling seed stands

Acacia seed stand/Progeny tests

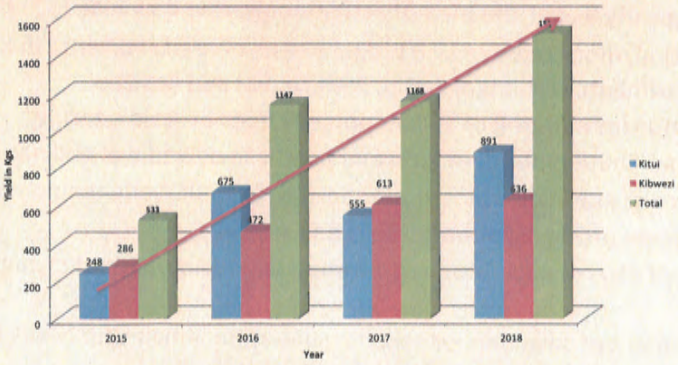
Observations

- Require urgent weeding or slashing
- Weeding was done in January, April & November 2018.
- Pruning was done in February, May, July & November 2018

Management of Progeny Trials

All progeny trial sites were last weeded in July and December 2018

Melia Nuts Production In Kitui and Kibwezi



Training

A very useful training session on R Statistical package for selected project staff was carried in December 2018

Way forward

Most activities for 2019/20 stalled due to lack of financial resources from KEFRI and Counterpart Funds. If funds are available, the following activities need to be undertaken urgently as per the plan of activities approved by last (3rd) JCC:

1) Data collection/monitoring of all 8 progeny tests of *Melia volkensii* in Kitui, Kibwezi, Marimanti, Gaciongo, Embu, Ikithuki, Voi and Kasigau
2) Data collection/monitoring of all two progeny tests of *Acacia tortilis*
3) Establish a pollination booth at Kitui and purchase of artificial pollination tools
4) Maintenance of sites where there is a shortfall from JICA site maintenance funds
5) Pruning of seed orchards for both Melia and Acacia
6) Continuing of Physiological studies to complete development of drought tolerance indices
7) Commencement of selection for second generation families for Melia (subject to 1 above, where analyzed results of data will be required)

Safeguarding the breeding goal

Goal: Quality plantations of indigenous species are extended in the ASALs of Kenya

- Fingerprinted all the materials conserved at Tiva and Kibwezi using molecular techniques
- Established an elaborate improved *Melia volkensii* seed supply system in Kitui
- Trained nursery owners – ultimately should be registered with KEFRI

Emerging challenges

Improved Melia seeds being distributed through un-elaborate KEFRI seed supply system like that envisaged in the project alongside unimproved Melia sees >>>>> adulteration potential

Recommendations

- Kitui and Kibwezi to concentrate on production of improved *Melia volkensii* seeds and seedlings
- The two Centers to strictly adhere to the vision of improved seed supply system
- Proper documentation of improved seed and seedlings supply to be maintained
- Ad hoc visits to nursery owners and farmers who have bought improved Melia seedlings from private and KEFRI nurseries and documenting hectarage under improved Melia

2/21/2019 21

22

Appendix 5-1-6

Report of short term expert (Project management)

Expertise	Name	Term
Project Management	Mr. Hidetaka Ichikawa	15～25 May. 2019
Project Management	Mr. Taiki Kobayashi	15～25 May. 2019
Project Management	Mr. Shizuo Kamizore	15～25 May. 2019

1. Itinerary

Date	Activity
15 May. (Wed.)	Hitachi to Haneda, move to Doha
16 May. (Thu.)	Arrival at Nairobi
17 May. (Fri.)	Meeting with Japanese experts Meeting with KEFRI CP, Courtesy call to DG of KEFRI
18 May. (Sat.)	Making report
19 May. (Sun.)	Move to Kilifi
20 May.(Mon.)	Observation of KOMAZA nursery, meeting with their Staffs Observation of Voi sub PTS
21 May. (Tue.)	Observation of Casigau PTS/ASS, Kibwezi PTS/ASS Move to Kitui
22 May. (Wed.)	Meeting with KEFRI Kitui Centre CP. Observation of nursery, seed orchard, PTS/ASS in Tiva Move to Nairobi
23 May. (Thu)	Attending the 8th Program Management Unit meeting Move to Doha
24 May. (Fri.)	Doha to Haneda
25 May. (Sat.)	Haneda to Hitachi

2. Result of major activities

2.1 Working plan of Component 4 (Tree breeding)

- Meeting with JICA and JICA experts

In the morning 17th of May, at JICA Kenya office we explained JICA officer and CADEP experts about this year's annual work plan. They asked that the proceeding of the project should be explained them on every business trip as possible, and stressed that necessity of making brief explanation tool for stakeholders. We also stated the purpose of this business trip including requesting sending periodical monitoring report to KEFRI.

- Meeting with CP (Photo1)

In the afternoon of the day, we visited KEFRI head quarter and discussed about the project with Mr.Kariuki, Assistant Component manager of CADEP (Dr. Muturi, Component manager of CADEP, was

absent).

Then we confirmed that recent assessment of PTSs(Jan-Feb,2019) are yet to be done by KEFRI at present due to lack of funding, and they decided to skip this time assessment, are going to do so on next July. Regarding personal transfer, Dr.Cheboiwo promoted as Director of KEFRI, Mr.Kariuki's transfer was officially canceled. We also confirmed current proceeding of considering MOU with KOMAZA that already legally confirmed by JICA office, final checking is underway in KEFRI.

In the afternoon of 22nd of May, we had a meeting with KEFRI kitui centre. We discussed about PTSs monitoring report, which had sent by Mr.Paul. Mr.Lvanda(KEFRI) agreed to send a report around once in two months.

2.2 8th Project management unit meeting(PMU) (Photo2)

In the morning of 23rd May, 8th Project management unit meeting was held at NHIF building hosted by Mr. Gordon from MoEF, attendance with CP, Japanese embassy, JICA Kenya office and Japanese experts. The important discussion points were following;

After discussion for the past minutes of meeting, future work plan after the mid-term review have been explained by the representatives of each component. Mr.Takahata, chief advisor of CADEP, suggested that we would have to prepare the documents for policy briefing, and requested attendees to discuss what is the definition of PB, how much the elements should be covered. Upon the request, attendees expressed various views such as not only good practice, but also failure and learning from the projects should be included in the documents. After that, each component shall prepare the PB documents within an activity of PDM.

Mr.Peter Ngugi(C2:KFS) pointed out that 2.5.4 Conduct basic market research on products of Melia volkensii, 2.5.5 Prepare strategy to promote Melia volkensii plantation in ASALs should be conducted in cooperation with KEFRI. With Dr.Muturi(KEFRI)'s consent, PO would be amended.

Reflecting on MTR, Dr.Muturi(C4:KEFRI) explained that KEFRI would try to hire younger researchers, decided to cancel Mr.Kariuki's transefer to Kitui centre to avoid being repercussion to the project. He also stated that MoEF decided to allocate its budget 16mKsh each KEFRI and KFS tomorrow or within a week as a result of meeting with CFO.

As a matter of other agenda, collaboration with other components was intensively discussed, CADEP decided to hold the 2nd interaction workshop in late July. Each components designated contact person, they would follow and discuss about the agenda and details of the workshop, at the same time confirmed not to hold next JCC until next year.

2.3 KOMAZA (Photo3,4)

- Site visit

On 20th May, we visited to Komaza nursery, their planting site in Kilifi county.

In the nursery, they hired 27 persons as permanent, shipped 50,000 plants/year (planning 70,000/next year). Also told me that it takes much cost on procuring water and sands for culture medium.

Two planting site to which we visited was local famer's field. Most trees were pruning but some were bending, its traits were not so good as well. Planting space was 5×5m square that is narrow compared to

BGF(there were 7×7m). Livestock are grazing in the meantime of growing. According to Mr.Charles who in charge of nursery, he wanted to space wider, to build seed orchards. He also explained that tree growth rate is varying by region, KEFRI had assessed had the data but not disclosed, so he exchanges the information with BGF counterparts.

After that, we visited to KOMAZA head quarter in the city of Kilifi. The management team explained about their past and future activities. Mr.Kumahira, senior manager, emphasized that they have a plan to expand its business from coastal area to inland Kenya, therefore they would cooperate with KEFRI to secure sustainable seed access.

KOMAZA has a wood preservative treatment facility in Kilifi. Harvested eucarypse trees are classified by diameter and treated by the CCA treatment machine, which was imported from South Africa. The CCA treated logs shipped for fences of meadows.It brings hundreds mKsh revenue per year. They also have a plan to produce charcoal.

- About KOMAZA

KOMAZA established in 2007, built nursery in 2008, intensively planted 2010-2012. After that, the area of planting were decreasing because they had apply themselves to take care of existing planting sites. In 2017, reformed its structure and resume planting activities, last year planted in Kwale County for the first time. Until now around 6,200 farmers joined the project, planted area is 15 thousand ha. Regarding planting species, most of them were Eucaryps in early days, however, later Melia increased to half of the planted area. As of 2019, KOMAZA occupy around half of annual afforestation/reforestation area in Kenya.

For facilitating the project, KOMAZA organized Field Extension Network as one of the restructuring plan in 2017. FEN consists of a Field manager (15 in total), 3 Field Officers (45) and 6 Facilitators (230). Each facilitator shall take charge of 20 to 30 capita. Activity is planned yearly, weekly and daily basis. The degree of achievement reflected on the map of their network system by color. If someone did not meet the target, the staff would try to improve by instruction.

(Q&A)

Q: Melia trees harvesting are yet to begin for now. How would you earn profit from Melia wood?

A: That is one of the main problem for the project. We would try to establish the value chain by 2025 when the harvesting is beginning. We also wish to own our sawn mill to add its value.

Q: In Japan, plants are sometimes withered and not well growing by some reasons.

How to extent plant survival/mortality rate in KOMAZA sites?

A: We decided to planting area on which based precipitation data and soil maps etc., so overall result is generally good. However, some of them were extremely bad for unknown reason.

2.4 Kasigau PTS (Photo5)

Kasigau PTS is theleast growth site among the three sites we visited this time in spite of higher precipitation than other sites. The cause is considered that quality of soil or cloning plant's applicability to the land etc., in any case, further assessment should be undertaken. Weeding itself has well done.

2.5 Voi Sub-PTS(Photo6)

The site was establish in 2015, better access to the main road between Nairobi and Monbasa. That makes

the site management and Melia growth better.

2.6 Kibwezi PTS, ,seed orchard(Photo7)

PTS is almost better growing, in seed orchard, however, a few trees are fell onto the ground with fruits that seems to be happen recently. That is considered that its growth are disproportionally too fast to cut branch, center of gravity is moved upper, then roots could not support its whole body of tree. Also having a problem in roots stock development with some reason.

2.7 Tiva PTS, seed orchard, nursery(Photo8)

The growth of Melia trees in PTS was going well with DBH:12 – 14cm, height:8m. it was found that the height growth would become moderate and the diameter growth is advancing gradually. Weeds on the ground was a few due to a regular weeding for assessment.

We observed Melia seed orchard in Tiva. Much bushes and weeds were found inside, because weeding had been suspended from last year. Introduction of bush cutters with engine for weeding is considered, and 2 times of weeding a year must be needed to keep suitable condition of seed orchard.

Acacia trees with superior growth in seed stand was growing to DBH:10cm and height:6m, and the stem of tree was standing straightly. The growth of Acacia is much better than expected, so thinning should be considered for appropriate management.

The nursery in Tiva was not so much used for Melia plant production compared to their capacity because of soil microbe. Nevertheless, KEFRI has a plan to build watering facility to revitalize the facility.

We also observed Melia planting site near PTS site where implemented by the past JICA social forestry project. We assumed that no human intervene has been there for 17 years.

3. Subjects for management

- We need to check the periodical PTSs/ASS monitoring report from KEFRI as discussed in this business trip.
- By the time of 2nd Interaction workshop to be held in late June, we will have to summarize what to do with other component (especially C2). In parallel, we need to prepare the documents for policy briefing.

4. Contact persons

Dr. Joshua Cheboiwo, Director, KEFRI
Dr. Gabriel Muturi, Component manager of CADEP, KEFRI
Mr. Albert Luvanda, Deputy Regional Director of KEFRI Kitui regional station, KEFRI
Mr. Jason Kariuki, Assistant Component manager of CADEP, KEFRI
Mr. Samuel Auka, Forester, KEFRI
Ms. Mari Miura, Senior Deputy Director, Global Environment Department, JICA
Mr. Shinjiro Amameishi, JICA Kenya Office
Ms. Yoko Okonogi, JICA Kenya Office
Mr. Keiichi Takahata, Chief Advisor, CADEP
Mr. Katsuro Saito, Deputy Chief Advisor/Forestry Extension, CADEP
Ms. Yuki Honjo, Coordinator, CADEP

Photos

Photo1　Meeting with KEFRI CP

Photo2　Project Management Unit Meeting

(Hosted by Mr. Gordon, C1 manager)

Photo3　KOMAZA nursery（Ganze　Kilifi）

Germination room（1,500～2,500 plants/box、frequent sterilizing and exchanging sand in the room）

Melia seedlings（covered by shade net）

Wood frame for counting plants（９×５）

Tanks for watering（tap water, it costs 2,000USD per month）

Photo 4　Ganze district plant farming

Melia（1 Acre）、Eucalyptus（3/4 Acre）per capita、sprouted by 4m height

Melia（planted 2016, pruned on 6m height）

Eucalyptus plantation（planted in 2014, 2015）

植

Melia（planted in 2016, 4m height）

Wood preservative treatment facility

KOMAZA head quarter（Mr.Kumahira, center）

Photo 5　VoiSub-PTS

small scale, but well managed

Photo6　2019/05/21　Kasigau PTS

With security person

Rope and wire were bitten by the tree

Trench for drainage（to process ground water in rainy season）

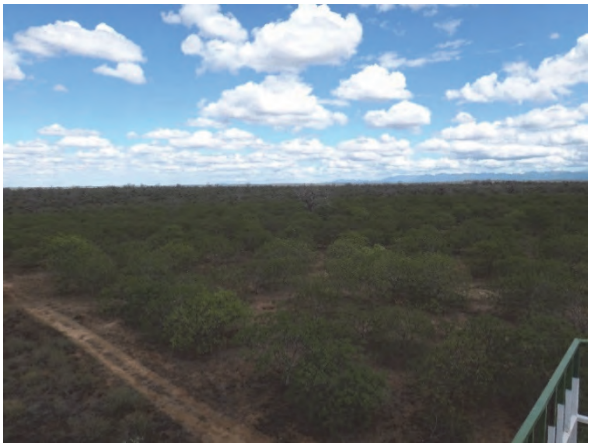
Photo 7　Kibwezi PTS、ASS

Melia seed orchard

Fallen Melia tree

Acacia seed standing

Melia PTS



Melia seed orchard from the watch tower

Acacia(near)、Melia PTS (far)

Photo 8　2019/5/22 Tiva PTS、ASS

There were many weeds and bushes in Melia seed orchard. KEFRI has a plan to purchase a brush cutter for weeding.

Entrance gate

Melia seed orchard （many weeds and bushes）

Melia seed orchard in Tiva

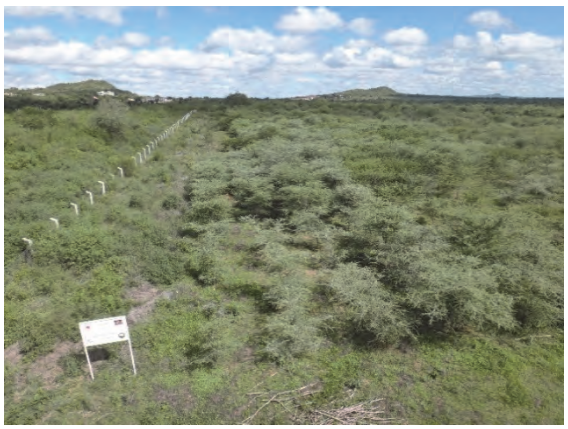
Acacia seed standing

Acacia seed standing

Tiva Melia PTS

Melia PTS（Planted in 2015(left)、2014(right) pruned by 4m height

Melia PTS(View from watch tower)



Acacia seed standing(from the watch tower)

Appendix 5-1-7

Report of short term expert（Project management）

Expertise	Name	Term
Project management	Dr. Masatoshi Ubukata	20-26 Jul.2019
Project management	Mr. Hidetaka Ichikawa	20-26 Jul.2019

１． Itinerary

Date	Activity
20 Jul.(Sat)	Hitachi to Narita, move to Doha
21 Jul.(Sun)	Arrive at Nairobi Move to Embu
22 Jul.(Mon)	Sites observation(FFS、BGF)
23 Jul.(Tue)	Attendance to CADEP component interaction workshop Sites observation(Tiva Seed Orchard, PTS, ASS)
24 Jul.(Wed)	Sites observation(Kituku Farm、Kibwezi Seed Orchard, PTS, ASS) Move to Nairobi
25 Jul.(Thu)	Meeting for component 2 and 4 in KEFRI HQ Courtesy call to JICA representative in Kenya Move to Doha
26 Jul.(Fri)	Move to Narita Move to Hitachi

２． Results of major activities

２．１ CADEP component interaction workshop

The short term experts from FTBC attended to the 2nd CADEP component interaction workshop, in order to deepen cooperation and to make synergy between each components of CADEP project, was held on 23rd July, Kitui.

At first, the representatives from each component presented their recent progress for the project. Mr.Kariuki from KEFRI explained about the activities of Component 4, which includes tree breeding for Melia volkensii and Acasia tortiriss from previous project. FTBC compiled a presentation documents file, and sent to CP(KEFRI), upon that KEFRI added another information such as back ground, etc..

In the wrap up, all attendees participated the general discussion regarding the following themes; “1. Aside from the Project activities, what should we go to achieve the Overall Goal? ”and “2. How can we improve Project implementation mechanism”We were able to have an active exchange of opinions as follows.

In the first theme, we should promote other tree species such as neem to ensure biodiversity. A farmer, who lives in the suburb of Nairobi and planted Moringa, has a sawn mill. Moringa has a lot of potential to develop regional economy. On the other one, various kind of documents in the project should be translated into Swahili because it is rather prevail than English in Kenya. In

terms of sharing the good practice in Component 5, we should do so not only good ones but also past failure examples for case study, County governments have not enough capacity to promote the activities in Component 2.

２．２　Observation of Farmers field school(FFS) activities site

All participants from each components divided into 2 groups, they observed Farmers field school activities in Embu county by Component 2. In general, FFS forms 20 to 30 villagers into a study group, they gather once a week at testing farm filed, check the growth of crops, livestock and trees, and learn about the common problem.

Such approach, which is originally developed by FAO, is already applied and adopted to many technical cooperate projects

There were around 20 improved Melia which was planted November last year. The groups regularly check the growth of Melia a month (a week for crops). Some of them were already withered, so they had to present no growth at the moment. It is assumed that problem might be caused by the following reasons;

1. KFS just hand over the seedlings, not instructed to plant on site.
2. Just a small number of the seedlings has been planted, so they could not replanting even if the survival rate is relatively low.
3. Little precipitation shortly after the planting, in the first half of the year.

２．３　Observation of Melia plantation site by private sector (Better Globe Forestry)

We observed a large scale Melia plantation site in Kitui county.

Better Globe Forestry (hereinafter BGF), which is a company to plant trees using fund collected from mainly European countries, has started tree plantation since 2007 near Kiambere dam lake.

BGF had planted neem trees in the area, but it was not successful for the plantation. BGF, therefore, changed plantation species from neem tree to Melia, and have implemented about 300ha Melia plantation since 2007. The superior plantation site in 2009 takes the growth of DBH: 16-22, H: 12-14m. The spacing of plantation is 4 by 4m, and the expected log size is diameter: 40-50cm and height:5-6m. BGF aims to export Melia to European countries as material for furniture making as well as mahogany wood. 5,000 farmers have contracted with BGF for Melia plantation (only this year they will acquire another 2,600 farmers) , and BGF will buy the logs from the farmers. BGF has furthermore a plan to build a saw-mill near future.

Seeds to produce seedlings have been collected from superior specific mother trees that are selected from the Melia plantation sites. They produce around 500 thousand seedlings a year. BGF already purchased improved Melia seeds from KEFRI two years ago, they are keen to establish Melia seed orchard to get high quality seeds, and also Melia clone propagation. It is quite important that Continuous support and collaboration with the experts from component 2, 4.

２．４　Kituku Farm

Kituku Farm in Kibwezi, which is established by Mr.Jonathan Kituku, have 300 acre land. He runs a mixed management with hay, dairy farming and horticulture in addition to Melia planting, seed and seedling production that makes him a leading farmer in Makueni county.

He started Melia planting in 2005 with a help from KEFRI, planted 170 thousand trees in 2008. The spacing of plantation is 4 by 4m (he recommends 5 by 5m), glass is also planting under the

trees. Hay is selling 300Ksh per cube, glass seed is 1,500Ks/kg.

The price of Melia seed(local) is 7,000Ksh/kg, seedling is 50Ksh per unit. Melia nursery was established in 2009, he boasted the sprouting rate is quite higher than usual.

Regarding horticulture, planting mango trees was started in 2009, the net income from mango fruits accounts a considerable share of their finance. Last year, they produced mango 9 thousand kg, sold 15Ksh/kg, some of them were exported to China.

They are well known for their portfolio management which mixed long(Melia), middle(Dairy, Horticulture) and short term(Hay) production for cash income enable to realize stable management, that is introduced as a good practice to inside and outside from Kenya. Upon the reputation, government officials across the African continent visit to the farmland in the course of training program by international organization such as UNDP and FAO, an agricultural minister as well.

Melia growth in the plantation is not as good as improved Melia, it might be a better option that KEFRI optimize the Kituku nursery to expand its capacity of producing seeds and seedlings.

２．５ Site observation of Tiva, Kibwezi Seed Orchard, PTS, ASS

The workshop participants went to see both Tiva and Kibwezi site. Melia seed orchard in Tiva was at a stake of maintain the condition due to lack of funding, fortunately, weeded properly in this time. We imagined that KEFRI got a long-awaiting funding from MoFE to facilitate the project.

Melia PTS is well growth as ever, we found that some trees already have a flower and fruits. In Acasia seed stand, most of trees were standing by themselves, the growth difference among the trees is becoming significant.

Kibwezi is well managed at seed orchard, PTS and ASS as well as in Tiva although you do not need frequently weeding because of low understory vegetation by little precipitation. Some fallen trees we have seen in May was left as it is.

Those trees are less growth than Tiva but better when it comes to seed production,
rather lasting effect of tree designing by cutting and brunch pruning.
So it is assumed that Kibwezi has a good soil condition for Melia seed orchard.

２．６ Meeting for discussing about collaboration between Components 2 & 4

A joint meeting for how to facilitate the collaboration between Component 2 and 4 was held at KEFRI HQ on 25th July (Dr.Muturi (KEFRI, chair of the meeting), Mr.Nduati(KFS), Mr.Saito(CADEP), Dr.Ubukata(FTBC) and some experts from each component attended.). KEFRI also have a plan to hold a internal meeting at Kitui centre with Dr.Miyashita (FTBC) and Mr.Saito on August 2nd. Main agenda and discussion points were following;

- Improve accessibility to seeds and seedlings of improved Melia volkensii

  KEFRI has a goal to expand its capacity of seedling production to one million per year. However, current production is still lower than expected (around 300 thousand). Therefore, both component discussed about of possibility for optimizing KFS and Kituku Farm nursery, they would designate one or two officer from KEFRI and KFS to check these facility's state and capacity. Also, they exchanged the view about the option for establishing demonstration site so that people easily understand the growth difference between improved and indigenous Melia in order to promote improved Melia to public and private sector.

- Conduct basic market research on products of Melia volkensii

They will share the information about farmers from which both KEFRI and KFS have, will estimate the demand for Melia seed and seedling. At first KEFRI officer who in charge of social economic will make work plan, then KEFRI and KFS would discuss and decide how to carry out the plan.

- Proper silvicultural treatment of Melia volkensii

As for poor growth, it mentioned in 3.2, KEFRI expressed the views ;

They assumed that proper line seedlings might not be provided to adopt the soil of the region, ex, they found the fact that Voi-native one shows better growth in Marimanti, so would like to grasp the detail of seedlings condition. In terms of disseminating to farmers, Melia seminar was held, however, on-site instruction was not conducted. So presumably it was not better way of planting. KEFRI is developing Melia technical note for farmers, they hope the KFS would encourage FFS farmers to refer that.

- Update and way forward of MOU with KOMAZA

We understood that MOU would be signed soon as of May this year. In the meeting, however, Dr.Muturi explained that the detail of work plan is still under consideration, KEFRI would like to sign as a form of MOA (Memorandum of Agreement), MOU is just a general framework, MOA covers MOU article. The date of signing is still unclear, KEFRI wish to sign “MOA” with KOMAZA as earlier.

3. Subjects

○Maintenance of Gas exchange equipment(Li-6400)

The condition of gas exchange measuring apparatus (Li-6400; manufactured by Licor), which was equipped in KEFRI Kitui Centre 2014 by grant aid of GOJ, was checked with Mr.Muchiri (KEFRI Kibwezi sub-region centre). No abnormality was found, but he claimed that he did not bring it to seed orchard to measure the photosynthetic activities of trees because its battery had a little energy. Therefore, we should consider to replace the battery in time for using by Drought Tolerance assessment team.

○PTS assessment

The PTS assessment of January this year was skipped for some reasons. We asked KEFRI to do so next time certainly. The next assessment would be implemented in August.

4. Contact persons

Dr. Gabriel Muturi, Component manager of CADEP, KEFRI
Mr. Jason Kariuki, Assistant component manager of CADEP, KEFRI
Mr. David Muchiri, Kibwezi regional officer, KEFRI
Mr. Peter Nduati, Component manager of CADEP, KFS
Mr. Katsutoshi Komori, JICA Kenya Office representative
Ms. Yoko Okonogi, JICA Kenya Office
Mr. Kazuhisa Kato, Executive Director, JOFCA
Mr. Yoshihiko Sato, Professional Engineer, JOFCA

Mr. Shintaro Ishizuka, PASCO
Mr. Keiichi Takahata, Chief Advisor, CADEP
Mr. Katsuro Saito, Deputy Chief Advisor, CADEP
Ms. Yuki Honjo, Coordinator, CADEP

Photos

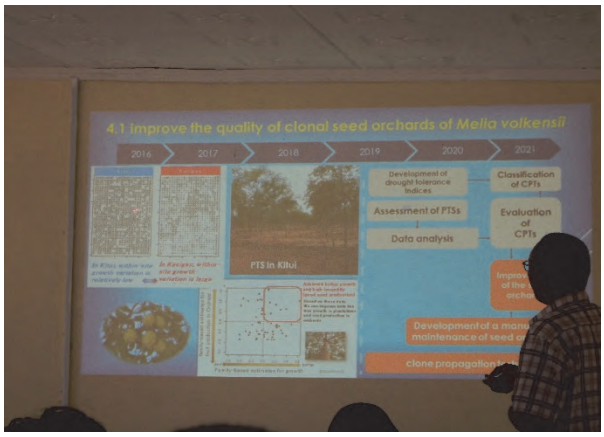


Photo1 Interaction Workshop
（Mr. Kariuki's presentation）

Photo2 Interaction Workshop
（General discussions）

Photo3 FFS activity
（Irabari FFS）

Photo4 Planted improved Melia at FFS site
（planted in Nov.2018）

Photo5 Better Globe Forest
(General explanation by officer)

Photo6 BGF Melia plantation
（Planted in 2009, found disease at trunk）

.

Photo 7　BGF Melia nursery
（seedling production under the tree）

Photo 8　Kituku Farm
（Mr.Kituku's explanation）

Photo 9　Kituku Farm nursery
（high sprouting rate）

Photo 1 0　Melia seeds
（collecting seeds from plantation）

Photo 1 1　Kituku Farm plantation
（4×4 m spacing）

Photo 1 2　Tiva seed orchard
（Properly weeded）

Photo１３　Tiva PTS
（Planted in 2014）

Photo１４　Kibwezi seed orchard
（Mr.Kariuki's site explanation）

Photo１５　Kibwezi Acasia seed stand
（Planted in 2015）

Photo１６　Kibwezi PTS
（Planted in 2015）

Photo１７　Meeting for collaboration between
C2 and C4（KEFRI HQ）

Appendix 5-1-7-1

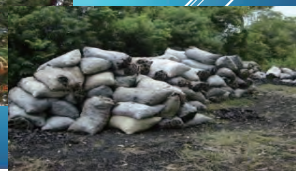
ACTIVITIES AND PLANS FOR COMPONENT 4

KEFRI & FTBC, FFPRI-Japan

2nd CADEP Interaction Workshop 21-24 July 2019

Acacia tortilis

- Provides fodder
- Fuelwood and charcoal
- Fuelwood of high calorific value (4400 kcal/kg)



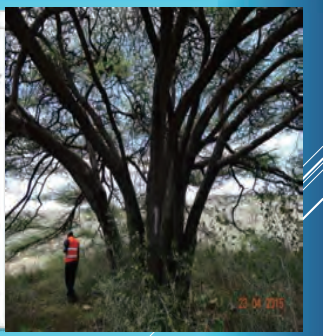
BACKGROUND

Melia volkensii

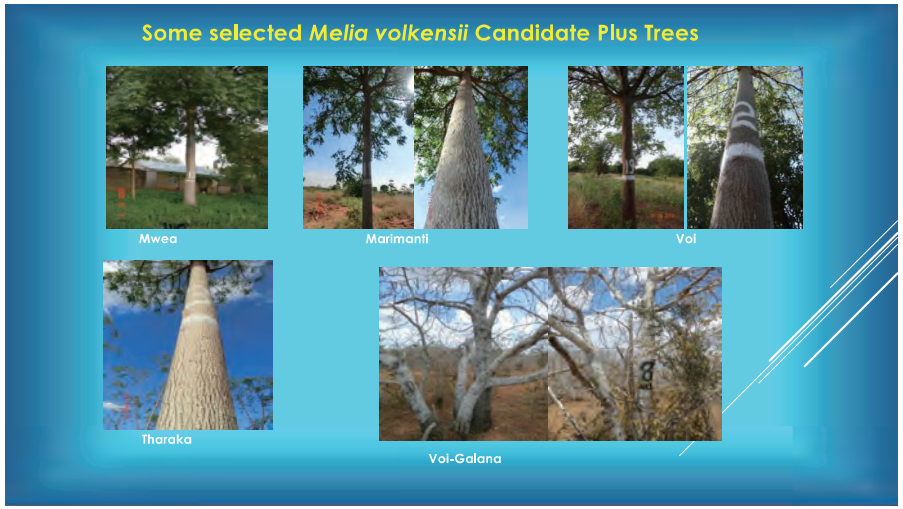
- A drought tolerant, termite resistant tree that produces high quality timber (used for making high value furniture, doors and windows frames)
- Provides fodder and fruits for animals
- Potential for large scale dryland forestry development

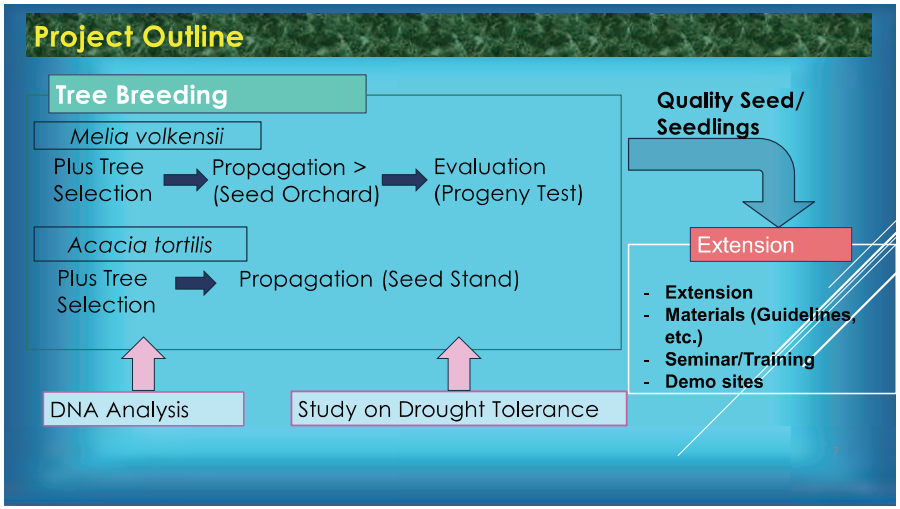
Stratification of *Acacia tortilis* and *Melia volkensii* natural populations in Kenya & Selection of Candidate Plus Trees (CPTs)

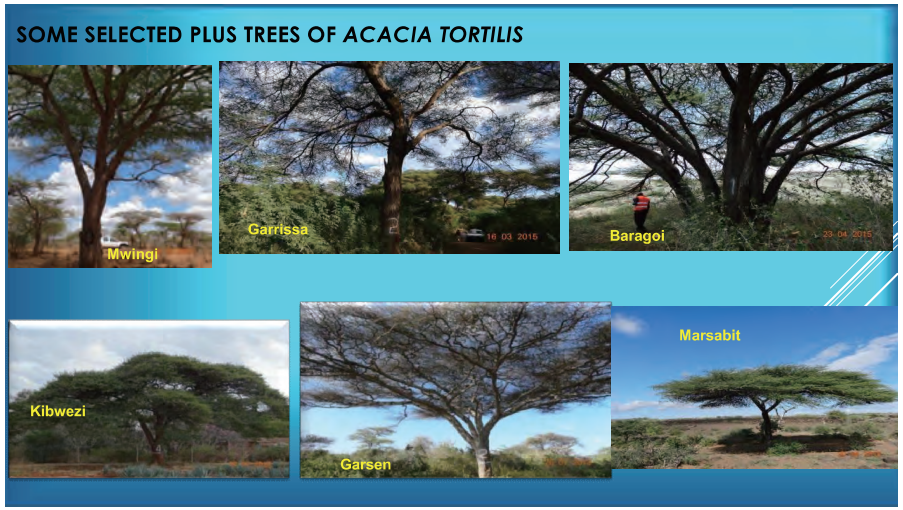
100 CP trees – M volkensii

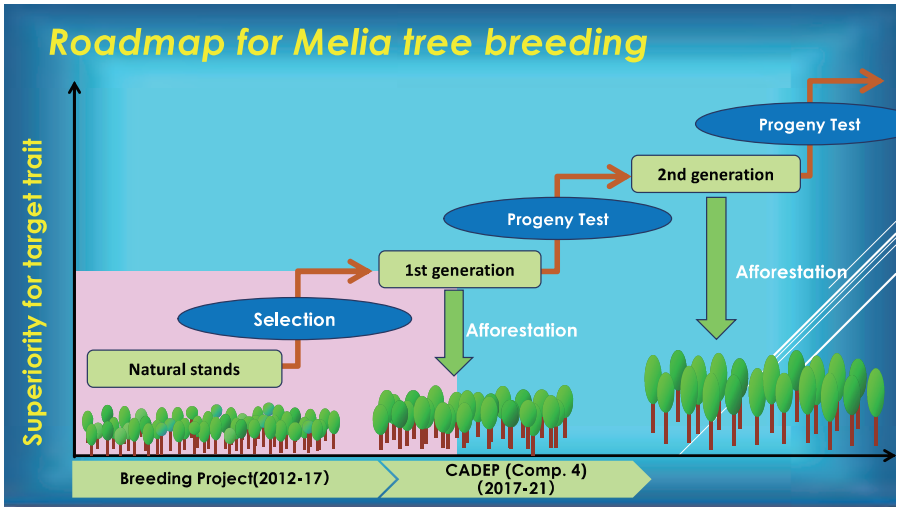


100 CP trees – A. tortilis

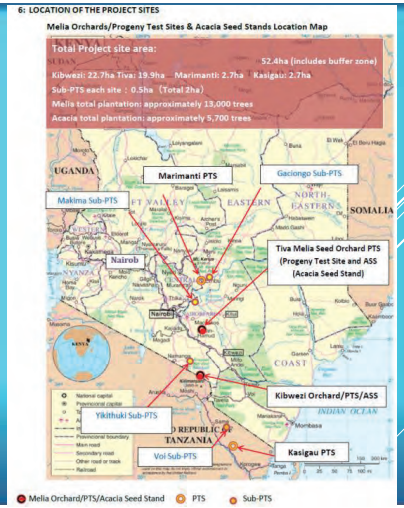

Some selected Melia volkensii Candidate Plus Trees
Mwea
Marimanti
Voi
Tharaka
Voi-Galana

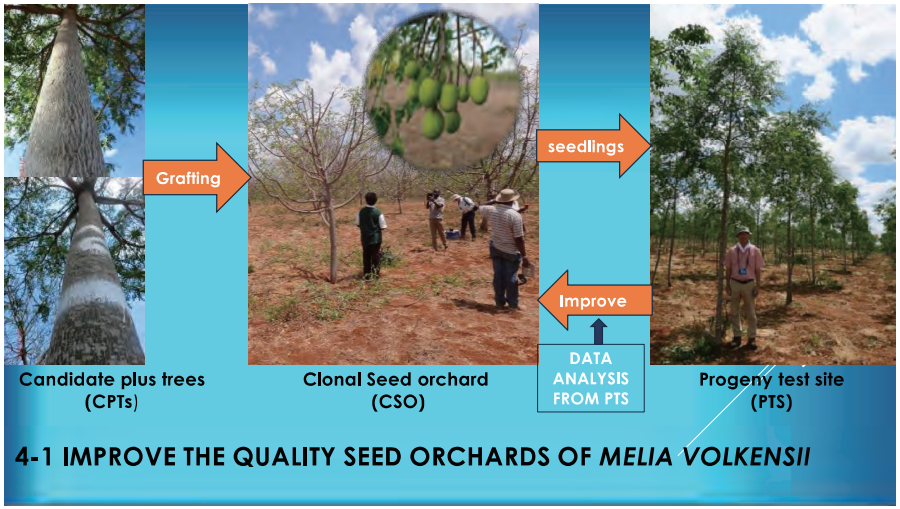

Project Outline
Tree Breeding
Melia volkensii
Plus Tree Selection
Propagation > (Seed Orchard)
Evaluation (Progeny Test)
Acacia tortilis
Plus Tree Selection
Propagation (Seed Stand)
DNA Analysis
Study on Drought Tolerance
Quality Seed/ Seedlings
Extension
- Extension
- Materials (Guidelines, etc.)
- Seminar/Training
- Demo sites


SOME SELECTED PLUS TREES OF ACACIA TORTILIS
Mwingi
Garrissa
Baragoi
Kibwezi
Garsen
Marsabit


Roadmap for Melia tree breeding
Superiority for target trait
Natural stands
Selection
1st generation
Progeny Test
2nd generation
Progeny Test
Afforestation
Afforestation
Breeding Project(2012-17)
CADEP (Comp. 4) (2017-21)

PROJECT SITES





4-1 IMPROVE THE QUALITY SEED ORCHARDS OF *MELIA VOLKENSII*

COMPONENT 4: 2017-2021

4-1 Improve the quality seed orchards of *Melia volkensii*

4-2 Study of artificial crossing toward 2nd generation of *M. volkensii*

4-3 Improve the seedling seed stands of *Acacia tortillis*

4-1 IMPROVE QUALITY OF S/O OF *MELIA VOLKENSII: ACTIVITIES*

4-1-1 Development and application of drought tolerance indices related to the growth of *Melia volkensii*

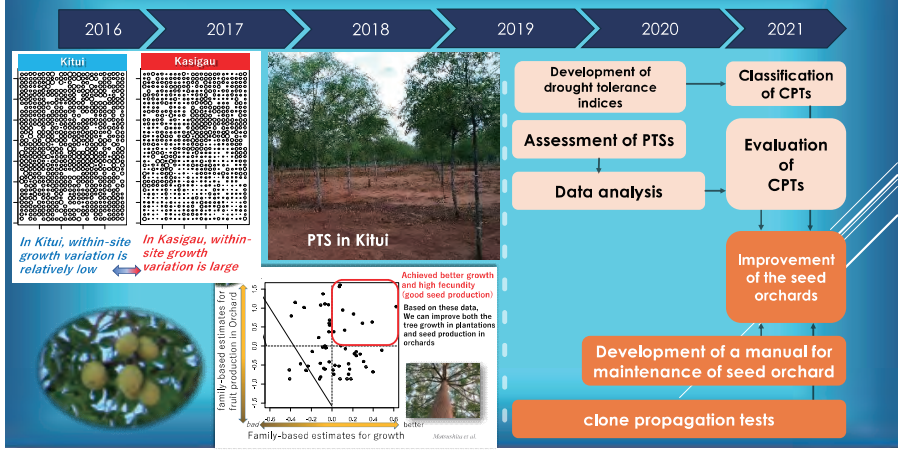
4-1-2 Evaluation of traits of plus trees

4-1-3 Improvement of the existing seed orchards through rogueing

4-1-4 Development of a manual for maintenance of seed orchard

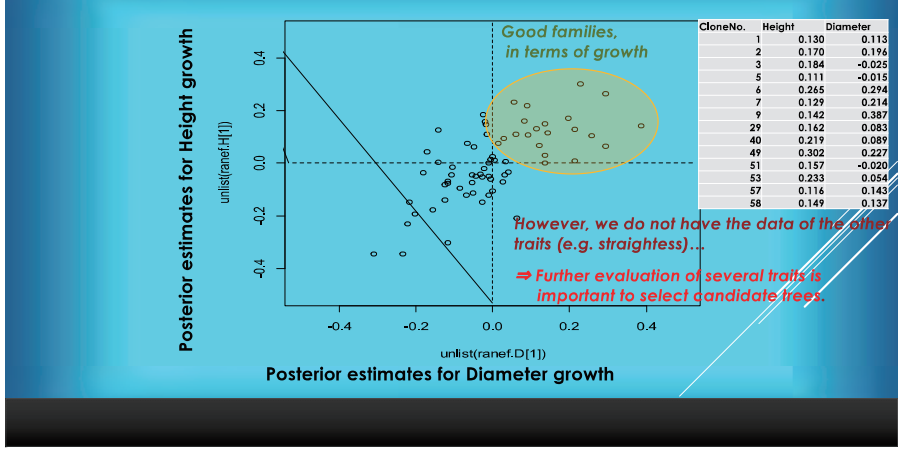
4-1-5 Study on clone propagation technique for *Melia volkensii*

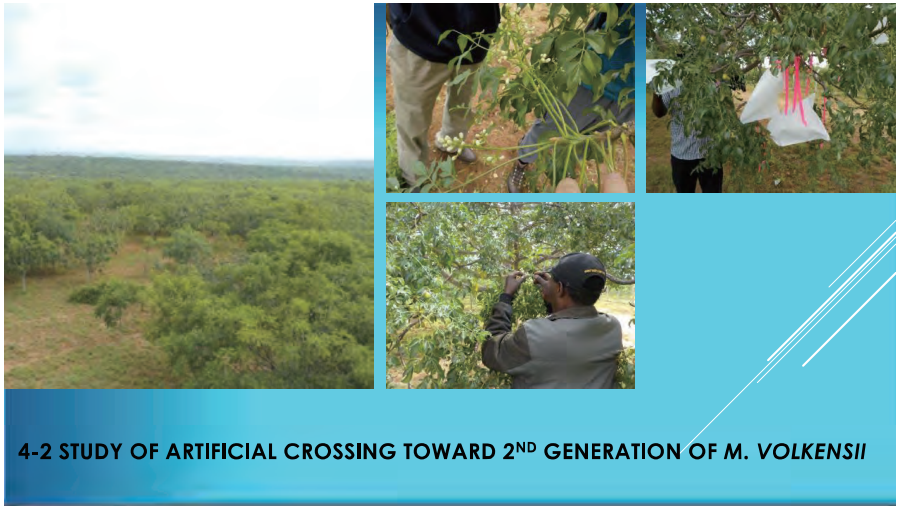
4.1 improve the quality of clonal seed orchards of *Melia volkensii*



Melia volkensii progeny trials assessment 2018 October

Family-based (mother-based) evaluation

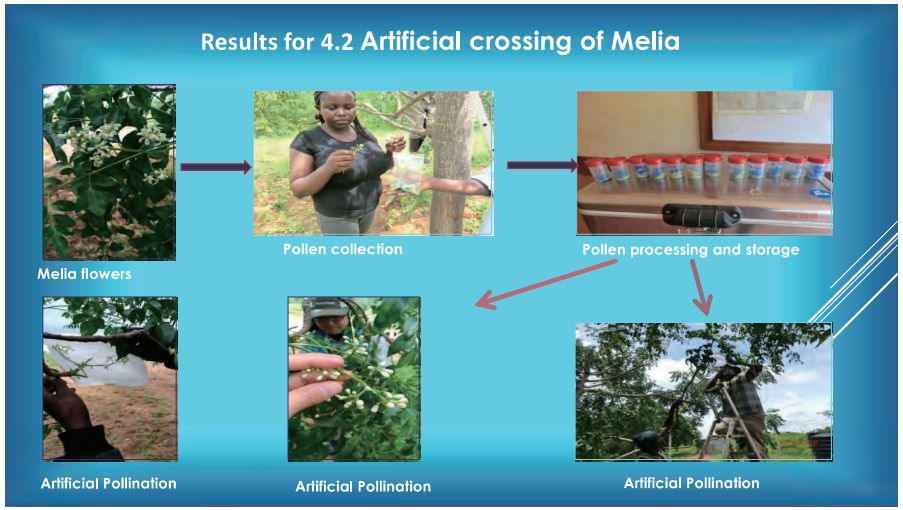


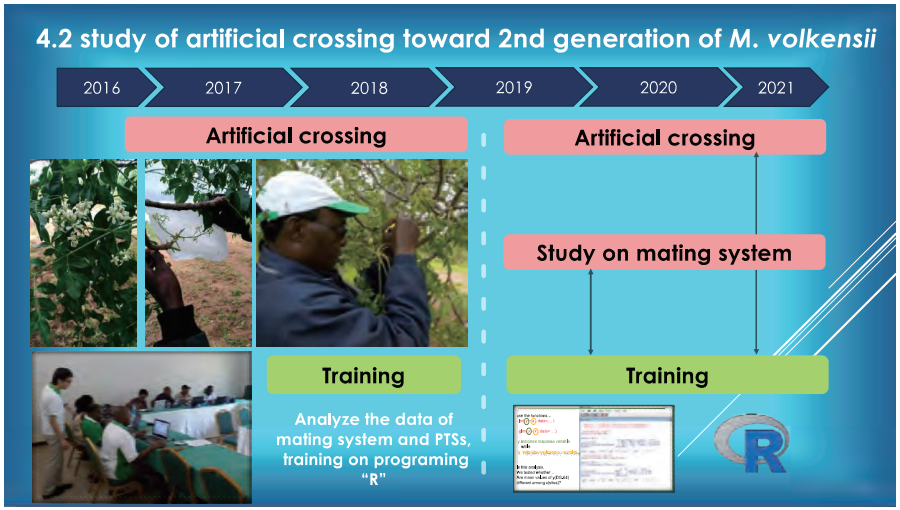


4-2 STUDY OF ARTIFICIAL CROSSING TOWARD 2ND GENERATION OF *M. VOLKENSII*

4-2-1 Study on mating system

4-2-2 Study for searching effective methods of artificial crossing





DROUGHT TOLERANCE STUDIES

1. **Monitor biophysical variables in project sites**
2. **Variation in growth among *Melia volkensii* CPTs**
3. **Relate growth to drought tolerance as manifested in:**

- Phenology
- Physiology
- Morphology

MEASURING PRE-DAWN WATER POTENTIAL USING PRESSURE CHAMBER

Trees are marked during the day and pre-dawn water potential measured before sunrise (at full cell saturation)

USING LICOR XT 6400 TO MEASURE STOMATAL GAS EXCHANGE

- Stomata conductance
- Water use efficiency
- Photosynthesis

Seeds collection from CPTs

Establishment of seedling seed stands(SSSs)

Seedling seed stand in Kitui

4-3 IMPROVE THE SEEDLING SEED STANDS OF *ACACIA TORTILLIS*

4-3-1 Assessment of seedling seed stands

4-3-2 Data analysis and evaluation of traits of plus trees

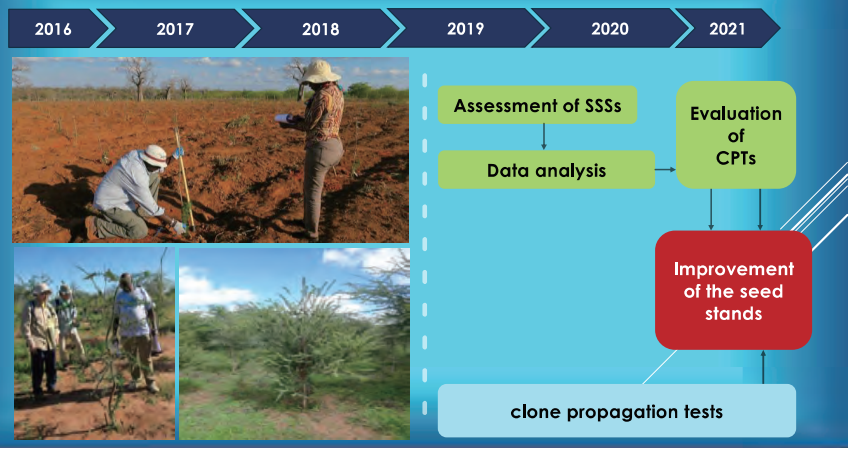
4-3-3 Improvement of seed stands

4-3-4 Study on clone propagation technique for *Acacia tortilis*

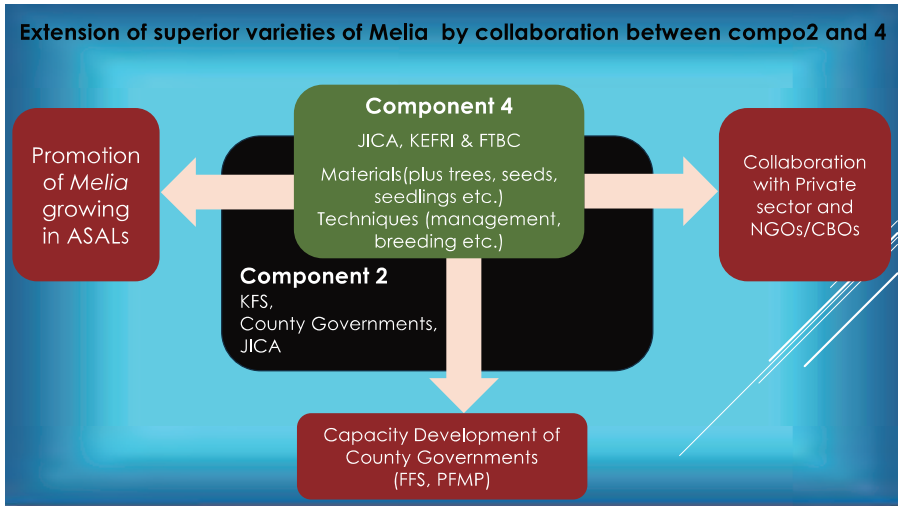
ACACIA SEED STAND/PROGENY TEST ASSESSMENT

2.5 years Acacia tortilis

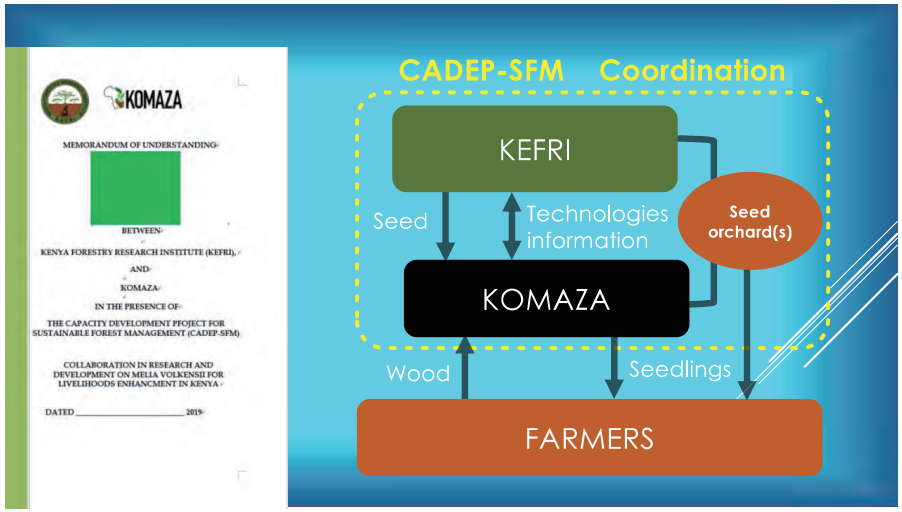
4-3 improve the seedling seed stands of *Acacia tortillis*



COLLABORATION WITH COMPONENT 2


Extension of superior varieties of Melia by collaboration between compo2 and 4
Promotion of Melia growing in ASALs
Component 4
JICA, KEFRI & FTBC
Materials(plus trees, seeds, seedlings etc.)
Techniques (management, breeding etc.)
Component 2
KFS,
County Governments,
JICA
Collaboration with Private sector and NGOs/CBOs
Capacity Development of County Governments (FFS, PFMP)

Training
A very useful training session on R Statistical package for selected project staff was carried in December 2018


KOMAZA
MEMORANDUM OF UNDERSTANDING
BETWEEN
KENYA FORESTRY RESEARCH INSTITUTE (KEFRI),
AND
KOMAZA
IN THE PRESENCE OF
THE CAPACITY DEVELOPMENT PROJECT FOR SUSTAINABLE FOREST MANAGEMENT (CADEP-SFM)
COLLABORATION IN RESEARCH AND DEVELOPMENT ON MELIA VOLKENSII FOR LIVELIHOODS ENHANCMENT IN KENYA
DATED _____ 2019
CADEP-SFM Coordination
KEFRI
Seed
Technologies information
Seed orchard(s)
KOMAZA
Wood
Seedlings
FARMERS

WAY FORWARD

4.1: IMPROVE QUALITY OF CLONAL SEED ORCHARDS OF *MELIA VOLKENSII*

- Assessment for Melia progeny tests to continue as scheduled though this has delayed during the last FY
- Data entry and analysis to be done
- Selection of best trees based on Drought Tolerance Index and Analysis of Progeny test data
- Maintenance of Seed orchard and PTS sites

4.3:Improve seedling seed stands of *Acacia tortilis*

- Assessment of PTS – This should be done twice annually (January and July).
- Data analysis and Evaluation of PTS – Basis for further improvement /selection – Being undertaken
- Improvement of seed stands through thinning -Using results of Data analysis Yr4- Oct 2018 and of January 2019 assessment
- Study on vegetative propagation techniques for Acacia –

4.2: Study artificial crossing of *Melia volkensii* for developing second generation

- Carry out studies on mating systems
- Continue artificial crossing of selected best families of Melia

Appendix 5-1-8

Report of short term expert（Project management）

Expertise	Name	Term
Project management	Dr. Masatoshi Ubukata	25Jan.-1 Feb.2020
Project management	Mr. Hidetaka Ichikawa	25Jan.-1 Feb.2020

１． Itinerary

Date	Activity
25 Jan.(Sat)	Hitachi to Haneda, move to Doha
26 Jan.(Sun)	Arrive at Nairobi Move to Embu
27 Jan.(Mon)	Meeting with CP at KEFRI HQ
28 Jan.(Tue)	Attendance to CADEP component interaction workshop Meeting with Japanese Experts
29 Jan.(Wed)	Move to Embu Sites observation(Marimanti PTS, Gaciongo Sub-PTS)
30 Jan.(Thu)	Visit Africa Children Education Fund Sites observation(Makima Sub-PTS, Yikithuki Sub-PTS, Kibwezi Orchard/PTS/ASS) Move to Nairobi
31 Jan.(Fri)	Meeting at JICA office in Kenya Move to Doha
1 Feb.(Sat)	Move to Narita Move to Hitachi

２． Results of major activities

２． １　Meeting with CP

（Arrangement for JCC presentation document）

On January 27, We have a meeting with Dr.Muturi for arranging the JCC document from component4 at KEFRI HQ. After discussing some topics, we accepted the most part of his views.

（Melia seed production）

Dr.Muturi explained that the estimated annual Melia seed production (fruit) in 2019-2020 would be increased to 5,000kg in Kibwezi, which is the highest production volume. Both sides agreed to the necessity of further establishing seed orchard by region to meet the increasing demand for improved Melia seed from farmers.

（Bearing the cost for assessment）

The cost for managing the clonal seed orchards from April to August 2019 was borne by KEFRI that saved the budget of CADEP to some extent. Therefore we offered Dr.Muturi that CADEP could cover the cost for the assessment of PTSs and related activities by the end of the fiscal year if it technically justified. He told that he had some option (ex. pathological assessment,

thinning PTS, etc.) if the budget could be allocated. He would consider what kind of activities should be prioritized, then respond soon anyway.

２．２　Joint Coordinating Committee (JCC) meeting（Photo1,2）

5th JCC meeting was held in the Ministry chaired by Mr. Gichu, Conservation Secretary of the Ministry, with the participation of CPs concerned, a representative of JICA Kenya office and Japanese experts. Besides, the county (Embu, Taita-Taveta) ministers who in charge of forestry and a treasury officer from MoEF attended for the first time.

In the meeting, the attendees from Component2 (KFS) and 4(KEFRI) mentioned about the collaboration between them, confirmed that further cooperation should be taken. KEFRI director Dr.Cheboiwo made closing remarks, stated that KEFRI wanted to further cooperate between JICA and KFS for succeeding the CADEP, to supply more Melia seeds to neighboring countries such as Tanzania, Ethiopia and Uganda, to enhance Melia seedling production to meet the increasing demand in collaboration with component2.

２．３　Marimanti PTS（Photo3,4,5,6）

The PTS is located along the dirt road from the highway, so it has been said difficult to access. Now the paving is underway that made easier to reach in spite of heavy rainfall.

In this time just weeding in the site, around 40% of the site has been done.2015 planted trees are growing to DBH16cm, H7m in maximum (Photo3). Some trees were about to fall because the roots were rotten, however, the growth was better as a whole. We found no significant growth difference to 2014 planted trees(Photo6). Although the weather observation equipment was not found by sight, it confirmed the site manager where it was.

２．４　Gaciongo Sub-PTS（Photo7,8,9）

The site is located 20minutes drive north from Marimanti PTS. The landowner, who is ex-principle of junior high school, have high motivation for Melia planting. 2015 planted trees are growing to DBH16cm, H7m in maximum, same growth trend as Marimanti PTS (Photo7,8). There were some blocks of Melia (bought seedlings from KEFRI) planted in 2017, planted seedlings from PTS last year, which adjacent to PTS. He boasted that he would not bought Melia seedlings from KEFRI any more because PTS trees came to have fruits and seeds. Then we visited his home, found that his Melia nursery in the garden. He succeeded to sprout the seeds in November last year, now nurturing around 20 seedlings (Photo9).

２．５　Africa Children Education Fund、Makima Sub-PTS（Photo10,11,12）

We visited Africa Children Education Fund (ACEF) in Embu. ACEF is the landowner of Makima Sub-PTS. There were a lot of facilities (primary school, child hospital, vocational training center) on the same site (Photo10). Managing Director Mr.Shiojiri told us that he attended a past JICA workshop which was held in Izaak Walton Hotel a few years ago, however, he rarely heard the current state of the project. We explained the proceedings of the project and would come here more often when we visit Embu.

The sub-PTS is located in the corner of Jump & Smile Children Centre, a children’s home to assist the orphans especially those with HIV and those parents died from the disease. Trees were growing maximum to DBH20cm, H8m (Photo11). We did not find new canker damage near the

ground（Photo12）.

2．6　Yikithuki Sub-PTS（Photo13,14,15）

The height growth of the site was 4 or 5m on average, it was the least developed in all PTSs. Many of which were thought to be fallen or withered, the selected candidate plus tree for the second generation was only 12 trees while Gaciongo and Voi are 16 each, Makima is 15. We estimated that the soil quality in the site was not suitable for Melia.

2．7　Kibwezi seed orchard/PTS/ASS（Photo16,17,18）

Kibwerzi is well managed at seed orchard, PTS and ASS as well as in Tiva although you do not need frequently weeding because of low understory vegetation by little precipitation. Some fallen trees we have seen in May and July were left as it is, however, still have fruits that enable us to collect seeds.

Those trees are less growth than Tiva but better when it comes to seed production,
the relatively longer-lasting effect of tree designing by cutting and branch pruning. So it is assumed that Kibwezi has a good soil condition for Melia seed orchard.

We also observed the state of ASS. Thinning was scheduled in January, but yet to be undertaken.

2．8　Meeting with Japanese experts

On the afternoon of January 28 after the JCC meeting, we explained the proceedings of Component4 activities to the Japanese experts upon the request.

2．9　Meeting at JICA Kenya office

On January 31, We discussed with JICA Kenya officers and Japanese experts about the following topics.

- Promoting practical breeding technics to neighboring countries
- After CADEP project
- Ensuring the income from seed selling
- Succession planning
- Follow-up the MoA, cooperation between KEFRI and KOMAZA

4．Challanges

oPMU（Project Management Unit）

PMU might be held in February or March if further discussion is needed.

5．Contact persons

Dr. Gabriel Muturi, Component manager of CADEP, KEFRI
Mr. Katsutoshi Komori, JICA Kenya Office representative
Ms. Yoko Okonogi, JICA Kenya Office
Mr. Kazuhisa Kato, Executive Director, JOFCA
Mr. Akinobu Senbo, PASCO
Mr. Keiichi Takahata, Chief Advisor, CADEP
Mr. Katsuro Saito, Deputy Chief Advisor, CADEP
Ms. Yuki Honjo, Coordinator, CADEP
Mr. Shiojiri Yasuo, Managing Director, Africa Children Education Fund

Photos

Photo1　JCC at MoEF

Photo2 JCC（Attendees from Component4）

Photo3　Marimanti PTS（Planted in 2015）

Photo4　Marimanti PTS（on weeding）

Photo5　Marimanti PTS (Planted in 2014)

Photo6　Marimanti PTS
（fallen tree caused due to soil runoff ）

Photo7　Gaciongo Sub-PTS (best growing tree)

Photo8　Gaciongo Sub-PTS

Photo9 Gaciongo Sub-PTS
（nursery at land owner's home ）

Photo10　Africa Children Education Fund in Embu

Photo11　Makima Sub-PTS
（canker damage at near ground level）

Photo12　Makima Sub-PTS
（canker damage at near ground level）

Photo13　Yikithuki Sub-PTS
（a better one in the site）

Photo14　Yikithuki Sub-PTS（slower height growth）

Photo15　Yikithuki Sub-PTS（fallen trees）

Photo16　Kibwezi Orchard（already weeded）

Photo17　Kibwezi Orchard（Melia flowering）

Photo18　Kibwezi ASS（yet to be thinning）

Appendix5-1-8-1

Capacity Development Project for Sustainable Forest Management (CADEP-SFM)

5th Joint Coordinating Committee (JCC) meeting

1. **Date:** 28th January 2020
2. **Time:** 10.00. am
3. **Venue:** 12th floor, MoEF Boardroom, NHIF Building
4. **Agenda**

Time	Item
9:30-	Registration
10:00-	Welcome remarks from the Chair
10:10-	Remarks from JICA Kenya Office
10:20-	Confirmation of minutes of the 4th JCC Mr. Keiichi Takahata (Chief Advisor)
10:35-	(1) The National Forest Reference Level for REDD+ (2) Achievements and future plans of Component 3 Mr. Peter N. Nduati (Component 3)
11:10-	Discussion
11:30-	Achievements and future plans (1) Component 1: Mr. Gordon Sigu (Component 1) (2) Component 2: Mr. Peter N. Nduati (Component 2) (3) Component 4: Dr. Gabriel Muturi (Component 4) (4) Component 5: Dr. Ebby Chagala-Odera (Component 5)
12:20-	Discussion
12:40-	Way forward
12:50	Closing remarks by the Chair
13:00 -	Lunch

Appendix 5-1-8-2

List of the 5th Joint Coordinating Committee (JCC) Meeting Participants
Capacity Development Project for Sustainable Forest Management in Kenya (CADEP-SFM)
28th January 2020

No.	Position	Name	Remarks
1	Principal Secretary, Ministry of Environment and Forestry (MoEF)	Chris Kiptoo	Chairperson of JCC
2	Conservation Secretary, MoEF		Project Director
3	Director Forest Conservation, MoEF		Project and Component 1 Manager
4	Head, Directorate of Forest Conservation, MoEF	Alfred Gichu	
5	Chief Conservator of Forests, KFS	Julius M. Kamau	JCC Member
6	Director, KEFRI	Joshua Cheboiwo	JCC Member
7	Deputy Head, Asia Pacific Division in Resource Mobilisation Department, National Treasury	Robert Gatonga	JCC Member
8	Ag. Director: Natural Resources, Environmental Management, Livestock Dev. & Food Security, Ministry of Devolution and ASALs	Monicah N. Kinuthia	JCC Member
9	Chair of County Executive Committee on Environment	David Ngeno	JCC Member
10	C.E.C.M in charge of Lands, Natural Resources, Physical Planning and Urban Development, Embu County Government	Josphat Kithumbu	JCC Member
11	C.E.C.M in charge of Water, Environment and Sanitation, Taita Taveta County Government	Gaper Kabaka	JCC Member
12	Principal Research Scientist, KEFRI	Gordon Sigu	Component 1 Focal Point
13	Assistant Chief Conservator of Forests, KFS	Peter N. Nduati	Component 2 & 3 Manager
14	Deputy Director, Biodiversity and Environment Management, KEFRI	Gabriel Muturi	Component 4 Manager
15	Regional Director, KEFRI Kitui DERP	Albert Luvanda	
16	Deputy Director, Technical Support Service, KEFRI	Ebby Chagala-Odera	Component 5 Manager
17	Chief Representative, JICA Kenya Office	Katsutoshi Komori	JCC Member
18	Project Formulation Advisor, JICA Kenya Office	Yoko Okonogi	JCC Member
19	Senior Programme Officer, JICA Kenya Office	John N. Ngugi	JCC Member
20	Second Secretary, Economic Cooperation Section, Embassy of Japan	Yuji Shigefuji	
21	Chief Advisor/Forest Policy Expert, CADEP-SFM	Keiichi Takahata	JCC Member
22	Deputy Chief Advisor/Forestry Extension Expert, CADEP-SFM	Katsuro Saito	JCC Member
23	Regional Cooperation Expert/Coordinator, CADEP-SFM	Yuki Honjo	JCC Member
24	Team Leader, REDD+ Readiness, CADEP-SFM	Kazuhisa Kato	JCC Member
25	Team Leader, Tree Breeding, CADEP-SFM	Masatoshi Ubukata	JCC Member
26	Tree Breeding Expert, CADEP-SFM	Hidetaka Ichikawa	JCC Member

Appendix 5-1-8-3

CADEP 5th JCC Meeting
28th Jan, 2020

Achievements and future plans for Component 4-(Tree Breeding)

Dr. Gabriel M. Muturi, Mr. Jason Kariuki - (KEFRI)
&
Dr. Ubukata and Mr. Ichikawa – FTBC

1 Progress and achievements

1.2 Activity 4-1 (ongoing)

Improve the quality of clonal seed orchards of Melia volkensii.

- 4-1-1:Development and application of drought tolerance indices related to the growth of *Melia volkensii* (ongoing)
- 4-1-2:Evaluation of traits of plus trees (ongoing)
- 4-1-3:Improvement of the existing seed orchards through rogueing (not yet)
- 4-1-4:Development of a manual for maintenance of seed orchard (not yet)
- 4-1-5:Study on clone propagation technique for *Melia volkensii* (ongoing)

2

1 Progress and achievements

1.1 Overall progress and achievements of Component 4

Each activity (4.1～4.3) situation is as follows,

・4.1 Improve the quality of clonal seed orchards of *Melia volkensii*
; ongoing

・4.2: Study artificial crossing of *Melia volkensii* for developing second generation
; ongoing

・4.3:Improve seedling seed stands of *Acacia tortilis*
; ongoing

1 Progress and achievements

1.2 Activity 4-1 (ongoing)

Improve the quality of clonal seed orchards of Melia volkensii.

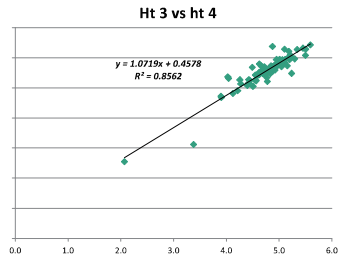
- 4-1-1:Development and application of drought tolerance indices related to the growth of *Melia volkensii* (ongoing)

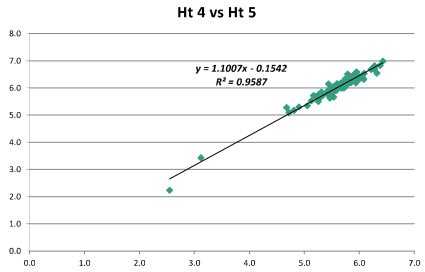
Seedling growth in test site(left:fast, right:slow)

3

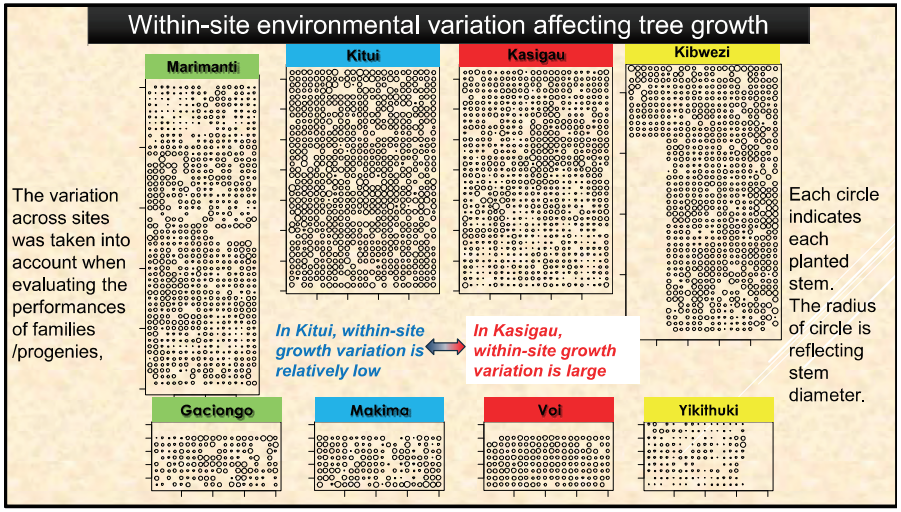
4-1.1- Analysis and second generation selection

4-year data was used for analysis Instead of projected 5 years





Within-site environmental variation affecting tree growth



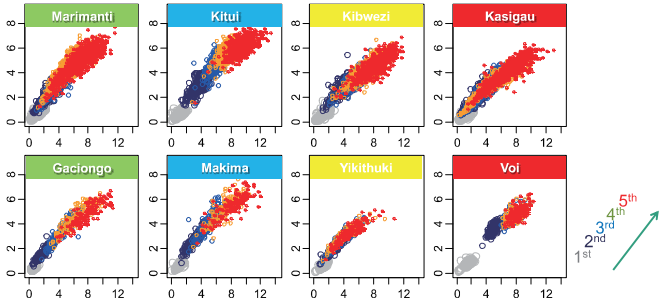
The variation across sites was taken into account when evaluating the performances of families /progenies,

In Kitui, within-site growth variation is relatively low ⟷ *In Kasigau, within-site growth variation is large*

Each circle indicates each planted stem. The radius of circle is reflecting stem diameter.

Height ~ Diameter relationships among sites

There is a large growth variation between sites



Heritability estimates for *Melia volkensii*, based on four-years-old data.

Stem volume:	0.23(0.05)
Tree height:	0.28(0.06)
Trunk diameter:	0.16(0.04)
Stem form:	0.16(0.04)
Fecundity:	0.13(0.04)
Healthiness:	0.07(0.03)

SEs are shown in ().

Site		#01	#02	#03	#04	#05	#06	#07	#08	All
N		748	794	769	754	153	137	138	133	3626
Diameter	Mean	12.9	9.0	10.0	11.0	11.6	10.4	8.6	10.3	10.6
	Max	21.5	17.4	17.6	20.5	15.3	19.2	16.5	16.2	21.5
	SD	2.1	2.3	2.3	2.1	1.2	3.3	2.1	2.1	2.6
Height	Mean	7.3	5.1	6.0	5.6	6.1	5.8	4.2	5.6	5.9
	Max	9.9	7.5	8.9	8.2	7.8	10.8	6.2	7.9	10.8
	SD	1.0	1.0	1.2	0.8	0.6	1.7	0.8	0.9	1.3

Although there were large among- and within-site environmental variation,
It is confirmed that there were significant genetic variations among families and relatively moderate-level heritability in *Melia*.

In the breeding analysis, "BreedR" package of "R" was used to obtain Heritability and BLUP estimations.

1 Progress and achievements

1.2 Activity 4-1 (ongoing)

Improve the quality of clonal seed orchards of Melia volkensii.

- 4-1-2:Evaluation of traits of plus trees (ongoing)

Marking "good" 2nd gen .progenies selected in Kitui 2015-PTS

Means at 4-yr-old: all and selected progenies

Tree height:	7.3 m →	8.2 m
Trunk diameter:	12.8cm →	15,2cm
Stem form index:	3.6 →	4.2

8

1 Progress and achievements

1.2 Activity 4-1 (ongoing)

Improve the quality of clonal seed orchards of Melia volkensii.

- 4-1-5:Study on clone propagation technique for *Melia volkensii* (ongoing)

Distribution of selected 2nd generation trees in all sites

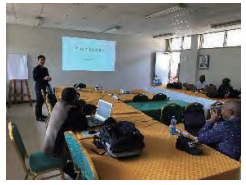
PTS SITE	Trees Selected	New Sub -population	Total No of new CP Trees
Marimanti (Main)	84	Breeding S/Population 1	100
Gaciongo (Sub)	16		
Tiva (Main)	85	Breeding S/Population 2	100
Makima	15		
Kibwezi (Main)	88	Breeding S/Population 3	100
Yikithuki (sub)	12		
Kasigau (Main)	84	Breeding S/Population 4	100
Voi (Sub)	16		
		TOTAL	**400**

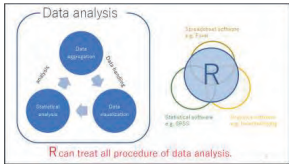
1 Progress and achievements

1.2 Activity 4-2 (ongoing)

Study artificial crossing of Melia volkensii for developing second generation

- 4-2-1: Study on mating system(ongoing)
- 4-2-2: Study for searching effective methods of artificial crossing(ongoing)





To analyze data correctly for the selection of next generation, a "free" useful statistical software "R" has been trained

1 Progress and achievements

1.2 Activity 4-3 (ongoing)

Improve seedling seed stands of Acacia tortilis

- 4-3-1: Assessment of PTSs(ongoing)
- 4-3-2: Data analysis and evaluation of traits of plus trees (ongoing)
- 4-3-3: Improvement of seed stands(ongoing)
- 4-3-4: Study on clone propagation technique for *Acacia tortilis*(ongoing)

12

1 Progress and achievements

1.2 Activity 4-3 (ongoing)

Improve seedling seed stands of Acacia tortilis

- 4-3-1: Assessment of PTSs(ongoing)
- 4-3-2: Data analysis and evaluation of traits of plus trees (ongoing)
- 4-3-3: Improvement of seed stands(ongoing)

13

1 Progress and achievements

1.2 Activity 4-3 (ongoing)

Improve seedling seed stands of Acacia tortilis

- 4-3-4: Study on clone propagation technique for *Acacia tortilis*(ongoing)

14

2 Likelihood of achieving indicators that are related to the Component 4

2.1 Output indicators

Indicator 4-1 Plus trees of *Melia volkensii* and *Acacia tortilis* are selected in the seed orchards and stands in Tiva and Kibwezi.	**Likely to be achieved by the end of the Project period.**
Indicator 4-2 Researchers of KEFRI acquire the skills of artificial crossing technique.	**Likely to be achieved by the end of the Project period.**

15

2 Likelihood of achieving indicators that are related to the Component 4

2.2 Project Purpose indicators

Indicator 5 Distribution system of seeds and seedlings of improved *Melia volkensii* is improved.	**Likely to be achieved by the end of the Project period.** Established an elaborate improved *Melia volkensii* seed supply system in Kitui

3 Constraints and issues to be addressed

- Sustain counterpart funding
- Expand Seed Orchards because of high demand of improved seeds

17

4 Future work plan

- 4-1-3:Improvement of the existing seed orchards through rogueing

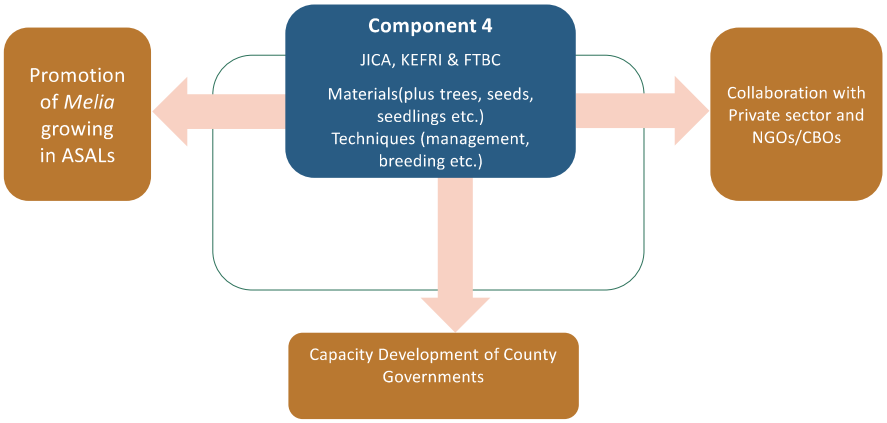
The two existing seed orchards are the only sources of improved seeds of Melia in Kenya, so the way of rogueing needs to be considered

- 4-1-4:Development of a manual for maintenance of seed orchard

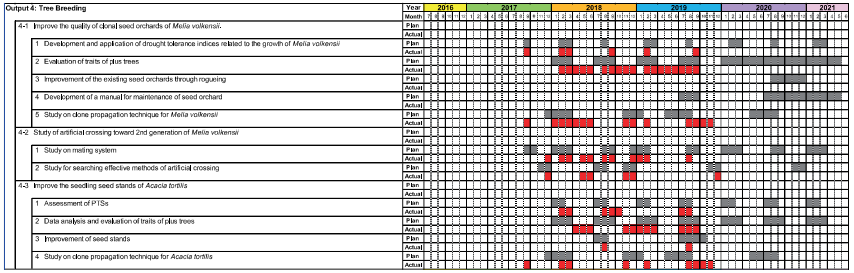
Create a manual of seed orchard by summarize the results of the Breeding project and CADEP.

18

Extension of superior varieties of Melia by collaboration between compo2 and 4



5 Work Plan for 2020-2021



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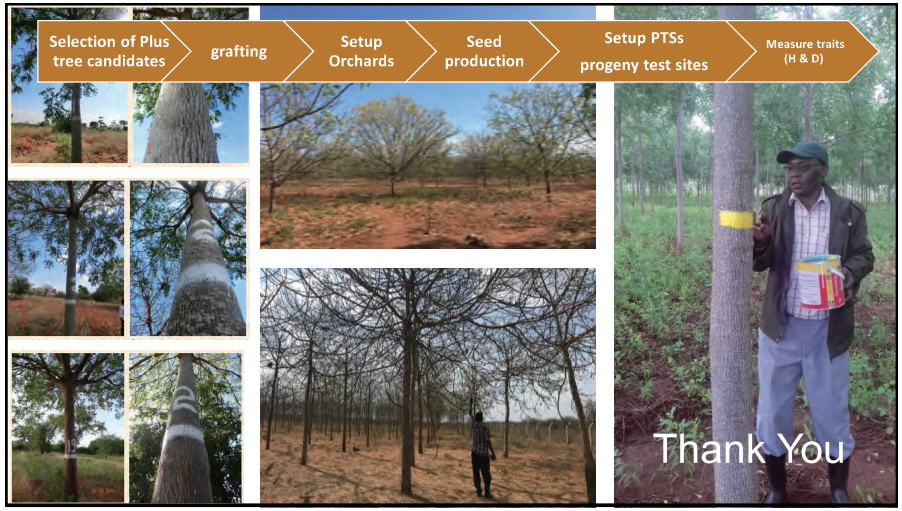


Appendix 5-2-1~7

Dispatched short-term experts (Component 4: Tree Breeding)

【Drought Tolerance】

Appendix 5-2-1

Report of short term expert (Drought Tolerance)

Expertise	Name	Term
Drought Tolerance	Dr. Koichiro Gyokusen	9～23 Sep.2017
Drought Tolerance	Dr. Eiji Goto	9～23 Sep.2017

○ Schedule

	AM	PM	Accommodation
09.09 (Sat.)		JAL330 20:00 Fukuoka- Haneda	
09.10 (Sun.)	EK313 00:30 Haneda	EK719 14:45 Nairobi	Kitui
09.11(Mon.)	Scheduling and measurement of grafted seedlings		Kitui
09.12(Tue.)	Collection of dendrometer and automatic camera Weather data collection and maintenance		Kitui
09.13(Wed.)	Preparation and arrangement for planting		Kitui
09.14(Thu.)	Preparation and arrangement for planting		Kitui
09.15(Fri.)	Measurement with morphological of grafted seedlings (Dimensions, pore and chlorophyll)		Kitui
09.16(Sat.)	Measurement with morphological of grafted seedlings (Dimensions, pore and chlorophyll)		Kitui
09.17(Sun.)	Move to Kibwezi Collection of dendrometer and automatic camera Weather data collection and maintenance		Kibwezi
09.18(Mon.)	Weather data collection and maintenance at Kasigau and Voi		Kibwezi
09.19(Tue.)	Weather data collection and maintenance at Yikituki Move to Embu		Embu
09.20(Wed.)	Weather data collection and maintenance at Marimanti and Gaciongo Move to Kitui		Kitui
09.21(Thu.)	Measurement of target tree diameter at Tiva Collection of equipment		Kitui
09.22 (Fri.)	Move to Nairobi	EK720 16:40 Nairobi - Dubai	
09.23 (Sat.)	EK316 3:00 Dubai - Osaka	NH1709 Osaka – Fukuoka 20:40	

2. Activities and results

2.1. Weather conditions at seed orchards and progeny sites

[Activities]

The weather data and soil water content data of Tiva and Kibwezi seed orchard have been collecting since July 2014. In this time the data from Feb. 2017 to Sep. 2019 were collected.

[Results]

The weather data of Tiva and Kibwezi seed orchard from Jan. 2017 to Sep. 2017 was shown in fig. 1 and 2. The both site data included the missing values due to the trouble of weather station, 46 days at Tiva from 6th Feb. 2017 to 20th Mar. 2017 and 9 days at Kibwezi from 2nd Feb. 2017 to 8th Feb. 2017. There were six times of rainfall period from 2015 to 2017. However, the variation of precipitation among rain seasons was large, especially in latest two times rainy season at Tiva remarkable decline of precipitation was recognized.

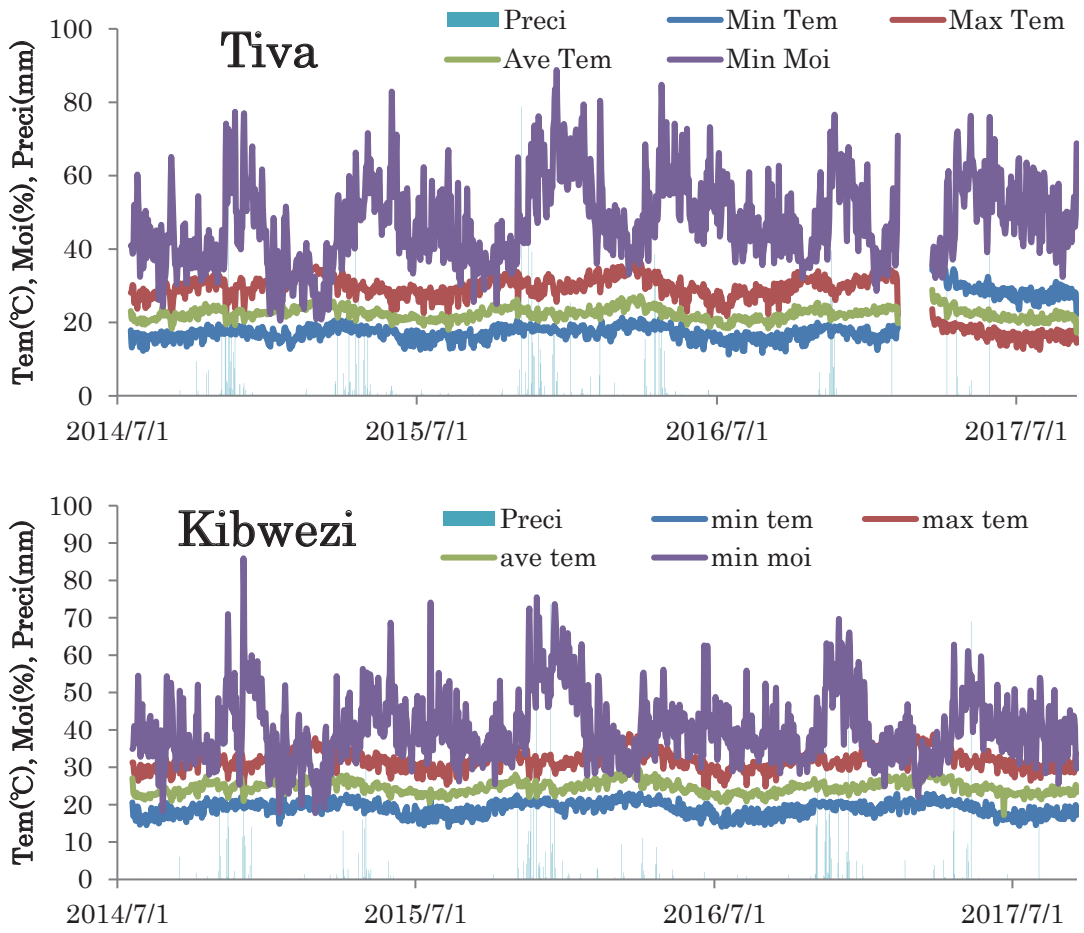
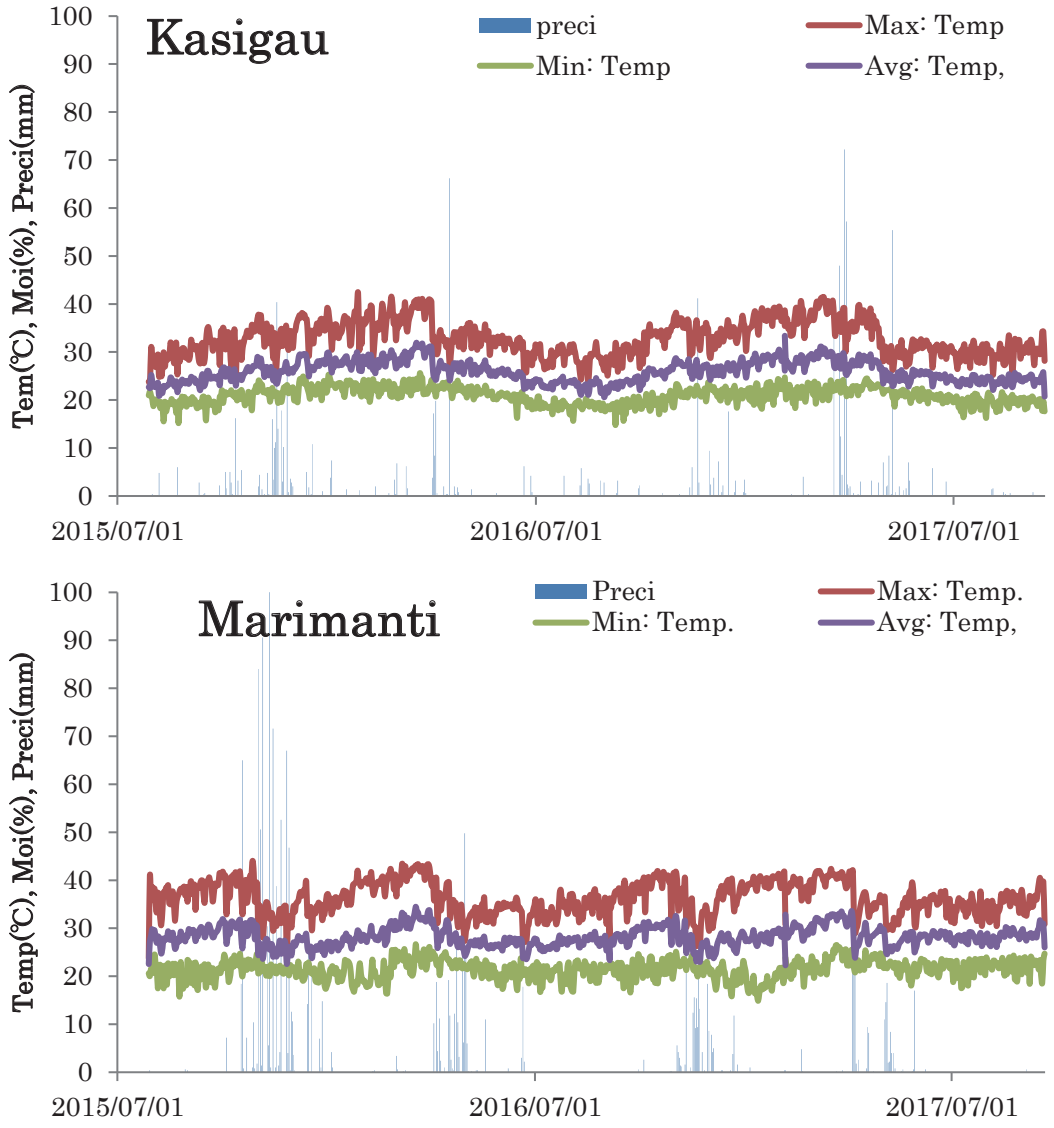


Fig.1 Weather Changes of Tiva and Kibwezi (Jul. 2014～Sep. 2017.9)

The weather data of Kacigau and Marimanti PTS from Jul. 2017 to Sep. 2017 was shown in fig. 2. Remarkable decline of precipitation was recognized at Marimanti.



Secondly, the temperature and humidity of every sites including Gaciongo, Makima, Yikituki, Voi were shown in table 1. The average of temperature of Tiva is lowest and the average of temperature of Marimanti is highest.

Table 1 Data of temperature and humidity of each site (Average from Feb. 2016 to Jul. 2017)

Site	Ave. of Max.RH%	Ave. of MinRH%	Ave. ofRH%	Ave. of Max.Tem℃	Ave. of Min.Tem℃	Ave. of Tem℃
Gacongo	79.3	36.7	65.8	33.5	21.0	26.8
Makima	88.1	41.7	65.5	29.6	17.8	23.2
Marimanti	65.1	36.5	49.8	36.2	21.8	28.4
Voi	88.4	41.2	67.4	31.6	20.5	25.2
Ykituki	89.7	40.2	65.4	29.7	18.3	23.6
Kasigau	79.6	55.7	59.5	32.8	20.8	25.8
Tiva	-	39.5	-	25.9	20.9	22.4
Kibwezi	-	49.3	-	32.3	18.8	24.7

2.2. The growth on Tive and Kibwezi seed orchards

2.2. Tiva と Kibwezi

[Activities]

Measurement of stem growth with dendrometers was completed in Tiva and Kibwezi seed orchards, which was continued from Jul. 2015. In this visiting time the data was collected and installed dendrometers were collected.

[Results]

Stem growing (average of 20 clones) and every day's changes of precipitation in Tiva and Kibwezi from Jan. 2017 to Sep. 2017 were shown in figure 2. The total precipitation in this period in Tiva, 130mm was lower than the Kibwezi one, 160mm. The average stem growing was lower than Kibwezi one because of the different of total precipitation. The start point of growing was observed just after precipitation at both sites. It is showed that the growing needs proper amount of precipitation at start point of growing. Eventually the growing seems to be starting at the achieving the proper amount of precipitation when the rain achieved at deep of root.

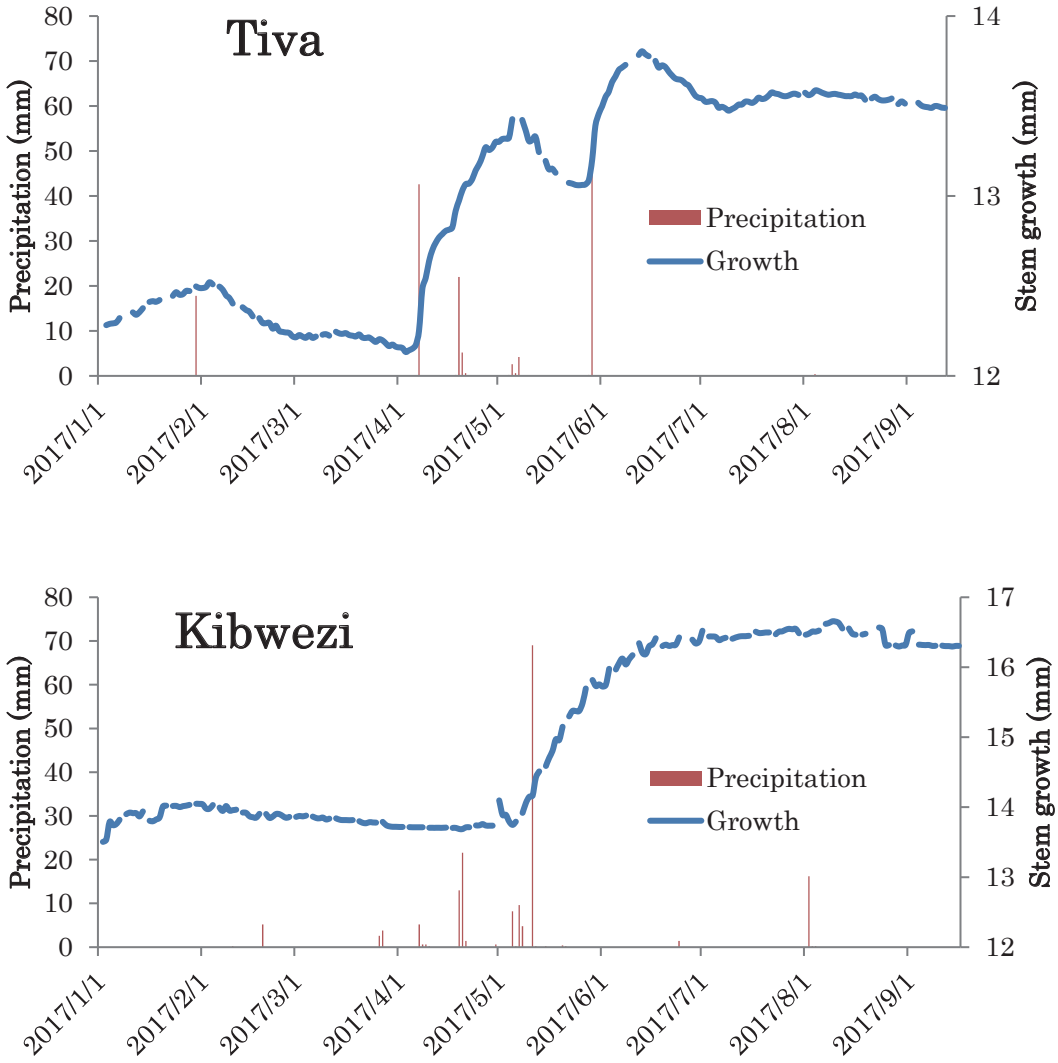


Figure2 Trends of stem growth and precipitation in Tiva and Kibwezi

2.3 Comparison of tree characteristic of fast and slow growth clones

Five fast growth clones (No. 18, 29, 40, 49, 54) and Five slow growth clones (No.1, 21, 31, 39, 45) were selected and the grafted seedling of them were produced at Dec. 2019. The tree growth and leaf chlorophyll content of grafting seedling of fast growth clones and slow growth clones were measured. The test site for plating of these clones at the open air was established.

2.3.1 The tree growth and leaf chlorophyll content of seedling

The results of measurement of the tree growth and leaf chlorophyll content of grafted seedling were shown in table2. The remarkable difference

among fast growth clones and slow growth clones was not recognized in this time.

Table 2: The tree growth and leaf chlorophyll content of grafted seedling of fast growth clones and slow growth clones

	no.49	no.29	no.40	no.54	no.18	no.39	no.21	no.45	no.31	no.1
Diameter(1)	7.7	6.4	8.2	7.6	6.2	7.4	8.3	7.8	7.9	6.7
Diameter(2)	11.6	10.9	11.8	10.7	11.8	10.5	12.3	12.8	10.7	11.3
Height	22.6	28.0	27.1	24.5	26.4	22.3	30.6	25.6	21.8	26.3
Chlorophyll	53.1	48.6	52.7	49.6	56.3	53.2	53.4	52.3	53.1	52.1

Diameter(1) shows diameter of scion and dameter(2) syows that of root stock. Chlorophyll content shows Spadvalue. Diameter(1) andDiameter(2) was calculated as an averae of 10 seedlings, and chlorophyll content was calculated as an average of ten leaves.

2.3.2 Plan of planting

These clones were planted at the open air and the progress of growing and physiology characteristic of the trees were compared in order to investigate the reason of appearing the difference among fast growth clones and slow ones. The test site planting was planned at December 2017 and the layout of planting was decided in this time. The test site was established in Tiva seed orchard where the vacant area was existed between Melia and Acacia.

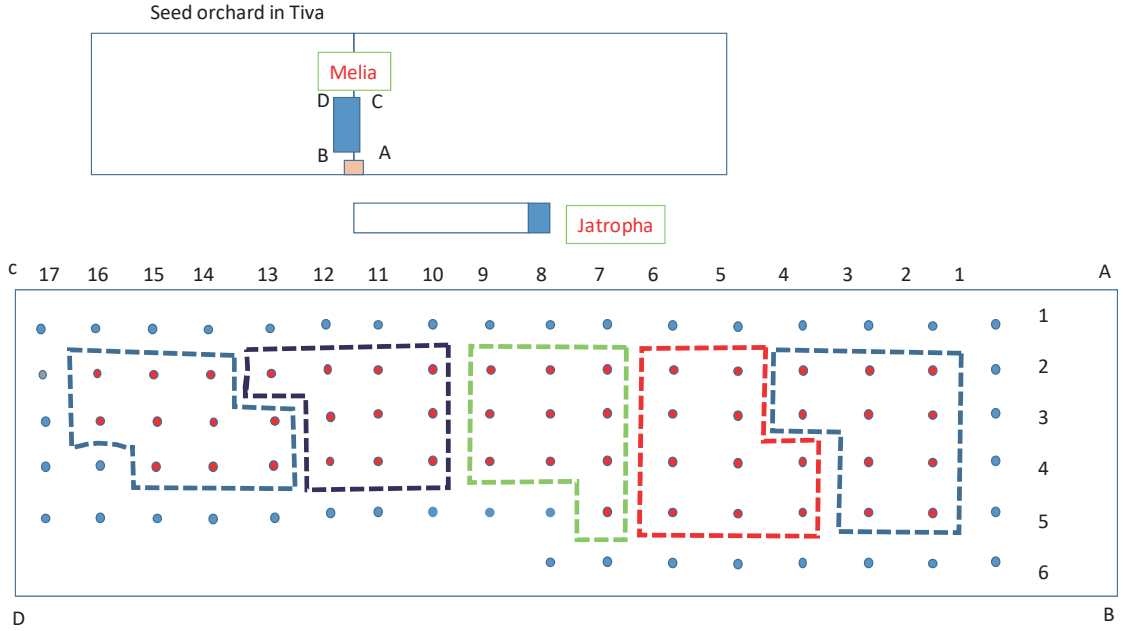


Fig.3 Location of planting test site and layout of planting clones

Layout of planting clones were shown in figure 4. Each clone planted one tree by one plot, totally there were five trees in one plot and planted non target trees at guard row. Effectiveness of guard row is recognized and the impact should be considered.

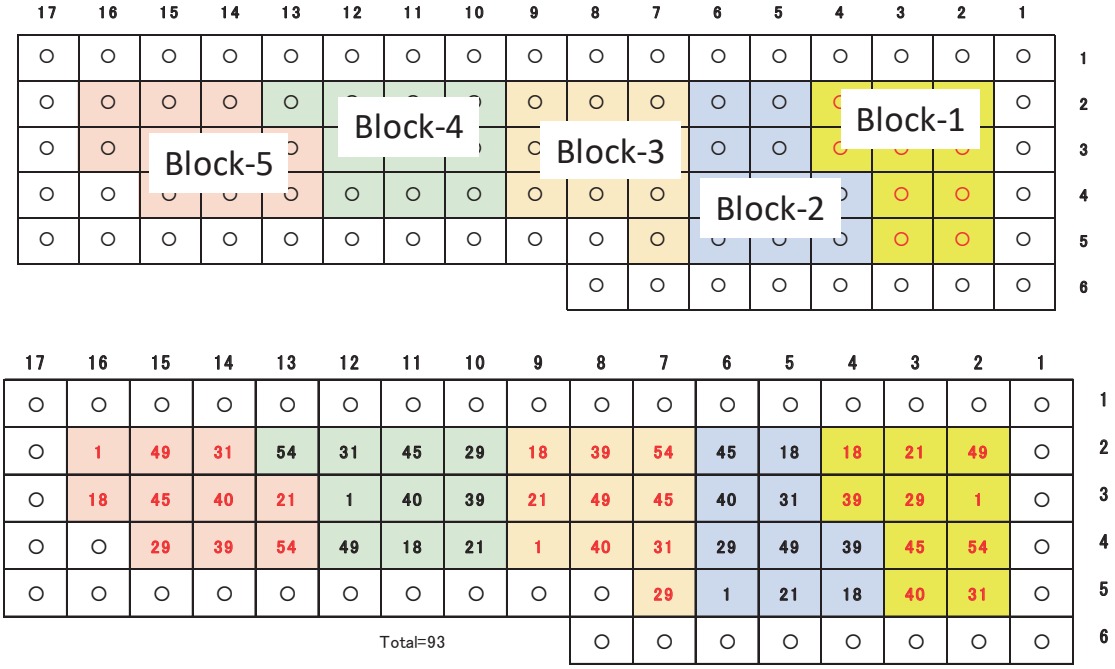


Fig.4 Layout of planting clones

Appendix 5-2-2

Report of short term expert (Drought Tolerance)

Expertise	Name	Term
Drought Tolerance	Dr. Koichiro Gyokusen	29 Jan.～8 Feb. 2018

1. Schedule

	AM	PM	Accommodation
01.29 (Mon.)		20:00 JAL330 Fukuoka-Haneda 21:40	
01..30 (Tue.)	00:30 EK313 Departure (TOKYO/HANEDA)	14:45 EK719 Arrival (NAIROBI)	Kibwezi
01.31 (Wed.)	Download of weather data at kasigau, Voi and Kibwezi. Replacement of a new weather logger at Kibwezi.		Kibwezi
02.01 (Thr.)	Dounload of weather data at Yikituki Move to Embu		Embu
02.02 (Fri.)	Dounload of weather data at Marimanti と Gaciongo. Move to Kitui		Kitui
02.03 (Sat.)	Maintenance of equipment and data analysis		Kitui
02.04 (Sun.)	Maintenance of equipment and data analysis		Kitui
02.05 (Mon.)	Download of weather data at Tiva seed orchad. Replacement of a new weather logger at Tiva		Kitui
02.06 (Tue.)	Measurement of seedling size at the newly established progeny test site		Kitui
02.07 (Wed.)	Travel to Nairobi (3hours)	16:40 EK720 Nairobi-Dubai 22:40	
02.08(Ths.)	3:00 EK316 Dubai-Osaka 17:10	19:35 NH1709 Osaka-Fukuoka 20:45	

2. Activities and results

2.1. Weather conditions at seed orchards and progeny sites

[Activities]

The weather data of Tiva and Kibweziseed orchard and that of Kasigau、Marimanti、Voi, Yikituki, Makima, Gaciongo progeny site had been collected. Six weather items, namely, solar radiation, temperature, humidity, precipitation and soil water content were collected in Tiva and Kibwezi seed orchards from Jul. 2014 to Jan. 2018. Three weather items of temperature, precipitation and soil water content were collected in Kasigau and Marimantiprogeny site from Jul. 2015 to Jan. 2018 and two weather items of temperature and humidity were collected in Voi, Yikituki, Makima, and Gaciongo from Feb. 2016 to Jan. 2018.

[Results]

The average daily air temperature of eight sites was shown in fig. 1 and table 1. The trends of seasonal change were similar in all sites. The average temperature was high in dry seasons (Jan.-Mar., Sep.-Oct.) and low in wet seasons (May-Jun., Nov.-Dec.). The order from maximum to minimum of average temperature was Marimanti, Gashiongo,Kasigau, Voi, Kibwezi, Yikiytuki, Makima and Tiva. Especially, the average daily temperature of Marimanti was 28.2℃ and it was considerably higher than that of other sites.

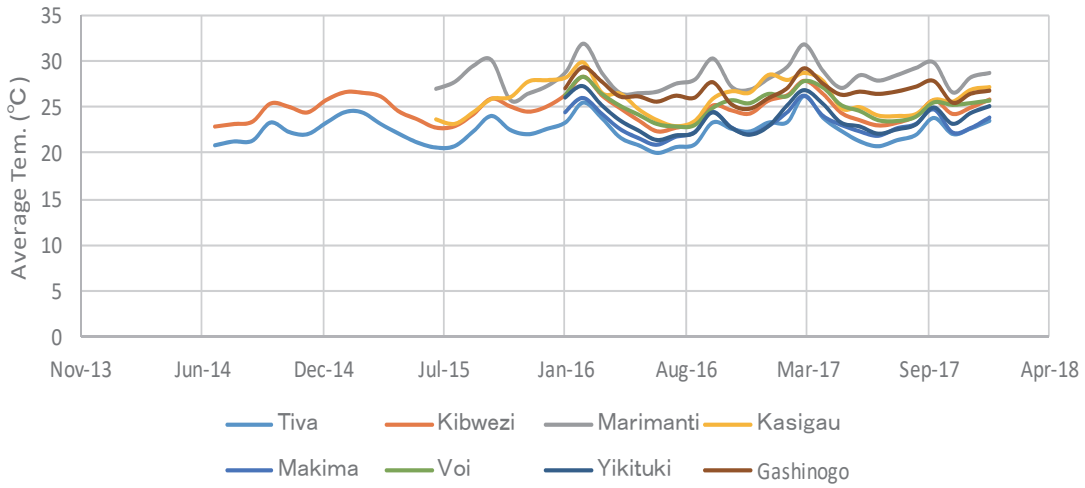


Fig.1 Changes of daily average air temperature of two seed orchards and six progeny sites.

Table 1 Changes of daily average air temperature of two seed orchards and six progeny sites.

2014	1	2	3	4	5	6	7	8	9	10	11	12
Tiva							20.9	21.3	21.4	23.4	22.3	22.1
Kibwezi							22.8	23.1	23.3	25.3	24.9	24.3
Marimanti												
Kasigau												
Makima												
Voi												
Yikituki												
Gashiongo												

2015	1	2	3	4	5	6	7	8	9	10	11	12
Tiva	23.4	24.5	24.5	23.2	22.2	21.2	20.7	20.8	22.4	24.1	22.6	22.1
Kibwezi	25.7	26.6	26.5	26.1	24.5	23.6	22.7	22.8	24.1	25.9	25.0	24.4
Marimanti							27.0	27.7	29.5	30.1	25.8	26.5
Kasigau							23.6	23.1	24.4	25.8	26.0	27.8
Makima												
Voi												
Yikituki												
Gashiongo												

2016	1	2	3	4	5	6	7	8	9	10	11	12
Tiva	22.7	23.4	25.6	23.8	21.7	20.9	20.1	20.7	21.0	23.4	22.7	22.4
Kibwezi	25.0	26.3	28.2	26.2	24.8	23.4	22.3	22.7	23.2	25.1	24.6	24.2
Marimanti	27.3	28.8	31.9	28.7	26.5	26.5	26.7	27.5	28.0	30.3	27.2	26.9
Kasigau	27.9	28.2	29.8	26.5	26.4	24.6	23.5	22.8	23.4	25.9	26.7	26.6
Makima		24.4	25.9	24.3	22.6	21.6	20.9	21.7	22.2	24.4	22.8	22.0
Voi		26.2	28.2	26.4	25.1	24.1	23.1	22.9	23.0	24.8	25.7	25.4
Yikituki		26.0	27.3	25.2	23.6	22.5	21.4	21.9	22.2	24.4	22.8	22.0
Gashiongo		27.1	29.3	27.8	26.2	26.2	25.6	26.3	26.0	27.7	25.4	24.9

2017	1	2	3	4	5	6	7	8	9	10	11	12
Tiva	23.4	23.4	26.3	23.9	22.5	21.3	20.8	21.5	22.0	23.9	22.1	22.7
Kibwezi	25.6	26.2	27.8	26.4	24.3	23.5	22.9	23.2	24.0	25.7	24.2	24.9
Marimanti	28.1	29.4	31.8	28.9	27.1	28.5	27.9	28.5	29.2	29.8	26.6	28.2
Kasigau	28.5	27.9	28.7	27.8	24.8	24.9	24.0	24.0	24.2	25.7	25.5	26.8
Makima	22.9	24.4	26.2	24.0	23.0	22.3	21.9	22.7	23.1	24.7	22.2	22.7
Voi	26.4	26.1	27.7	27.1	25.2	24.5	23.6	23.5	23.9	25.5	25.2	25.4
Yikituki	22.9	25.2	26.8	25.4	23.3	22.9	22.1	22.6	23.1	25.0	23.2	24.4
Gashiongo	26.0	27.1	29.2	27.6	26.4	26.7	26.5	26.7	27.2	27.8	25.5	26.5

2018	1	2	3	4	5	6	7	8	9	10	11	12
Tiva	23.6											
Kibwezi	25.8											
Marimanti	28.7											
Kasigau	27.1											
Makima	23.8											
Voi	25.7											
Yikituki	25.1											
Gashiongo	26.8											

The monthly precipitation of four sites were shown in fig.2 and table 2. The weather

data of precipitation was collected in Tivaand Kibwezi seed orchards and in Kasigau and Marimanti progeny sites. The data of Kasigau included the missing values from Nov. 8, 2017 to Jan. 31, 2018 because of the trouble of weather station.

There were two times of rainfall period in one year. However, period and amount of precipitation were different among experimental sites. The total precipitations of 2015 and 2016 years in Tiva, Kibwezi, Marimanti, Kasigau were 398, 342, 521, 310mm, and 359, 395, 441, 550mm, respectively. Total precipitation of 2015 in Kasigau was the minimum, but that of 2016 was the maximum. There is a need to continue the measurement because of the large variation of precipitation to know the water environment of the test sites.

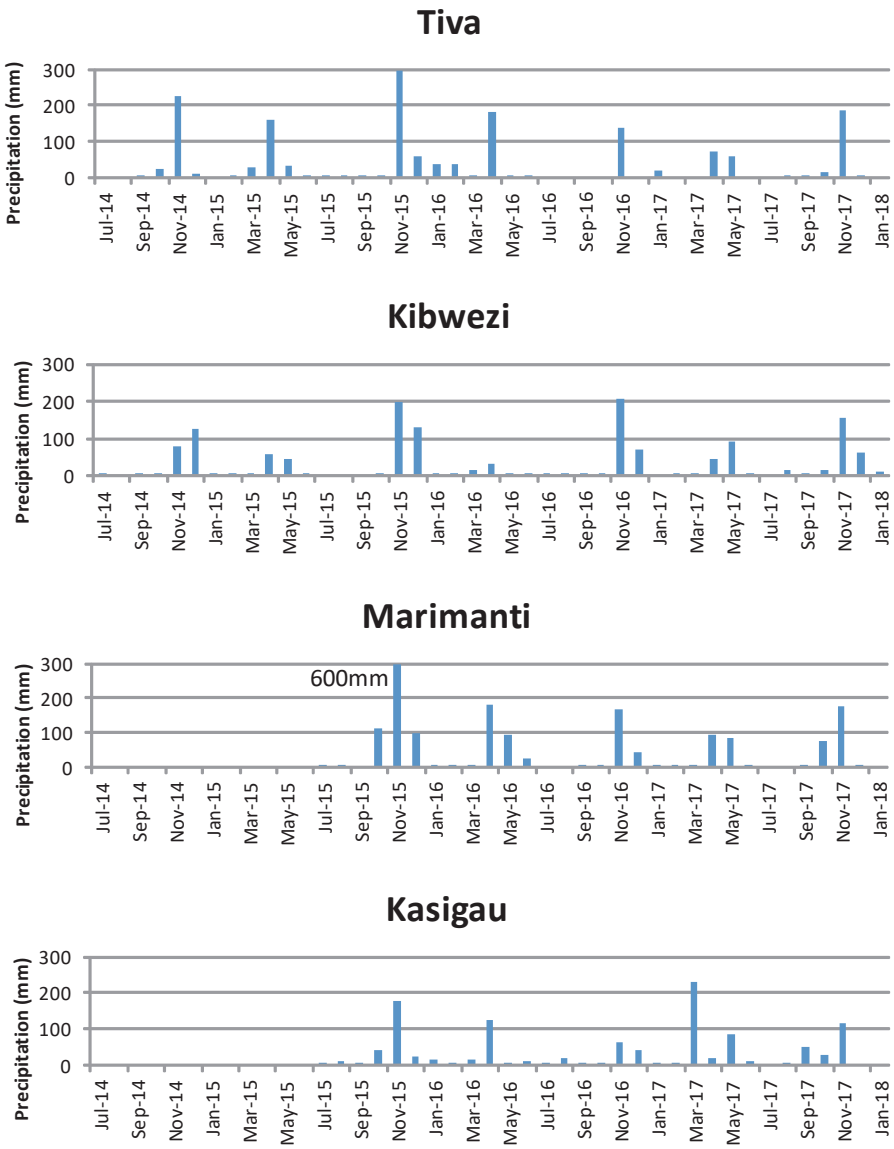


Fig.2 Changes of monthly precipitation of two seed orchards and two progeny sites.

Table 2 Changes of monthly precipitation of two seed orchards and two progeny sites.

2014	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva							0	0	2	24	226	10	
Kibwezi							0	0	6	3	79	124	
Marimanti													
Kasigau													

2015	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva	0	2	30	162	32	2	4	2	1	3	298	61	596
Kibwezi	0	2	4	58	46	1	0	0	0	1	199	130	441
Marimanti							0	1	0	113	677	101	
Kasigau							0	11	6	40	179	22	

2016	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva	37	35	1	181	3	2	0	0	0	0	139	0	398
Kibwezi	6	6	13	33	4	2	1	1	1	1	205	69	342
Marimanti	5	1	5	179	92	24	0	0	1	3	167	44	521
Kasigau	14	7	15	124	2	11	4	20	8	1	64	41	310

2017	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva	18	0	0	71	59	0	0	0	4	17	187	2	359
Kibwezi	0	5	6	43	93	1	0	17	1	15	154	60	395
Marimanti	1	6	1	93	84	1	0	0	1	74	177	4	441
Kasigau	0	5	232	19	85	9	0	5	52	26	116	0	550

2018	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva	0												
Kibwezi	9												
Marimanti	0												
Kasigau	0												

2.2. Progeny test site for comparing growth of the fast and slow growth clones

A progeny site was newly established in Dec. 2017 at Tiva to reveal the cause of fast and slow growth (fig.3). The current situations of planted trees were investigated this time.

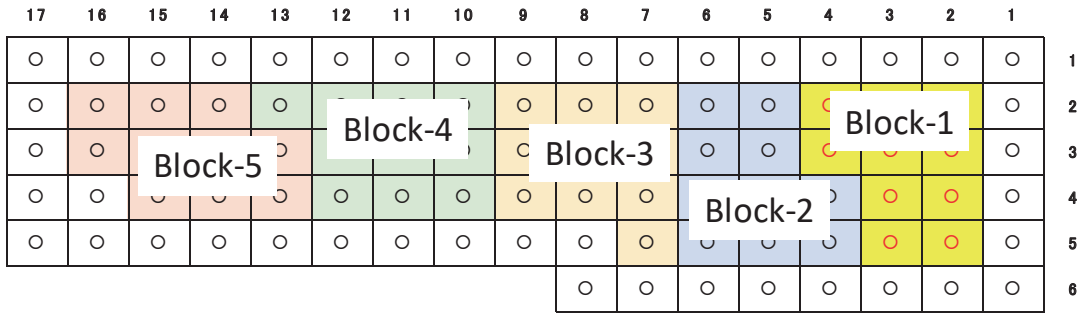


Fig.3 Layout of the progeny test site

Layout of each clone was shown in fig.4, and location map of replanted seedling was shown in fig.5. Twenty-four seedlings of planted ninety-three (26%) had died and replanted.

17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
45	31	54	40	49	45	40	31	54	29	45	39	54	40	40	31	54	1
54	1	49	31	54	31	45	29	18	39	54	45	18	18	21	49	45	2
40	18	45	40	21	1	40	39	21	49	45	40	31	39	29	1	31	3
21	18	29	39	54	49	18	21	1	40	31	29	49	39	45	54	40	4
18	21	29	54	18	45	29	21	49	29	29	1	21	18	40	31	39	5
					Total=93					45	29	54	39	40	40	45	6

Fig.4 Layout of 10 clones

17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
45	31	54	40	49	45	40	31	54	29	45	39	54	40	40	31	54	1
54	1	49	31	54	31	45	29	18	39	54	45	18	18	21	49	45	2
40	18	45	40	21	1	40	39	21	49	45	40	31	39	29	1	31	3
21	18	29	39	54	49	18	21	1	40	31	29	49	39	45	54	40	4
18	21	29	54	18	45	29	21	49	29	29	1	21	18	40	31	39	5
					Total=93					45	29	54	39	40	40	45	6

Fig.5 Location of replanted seedling （ replanted seedling）

The feature of planted seedlings was shown in table 3 and fig.6. Tree height of fast growth clones were a little higher than that of slow growth clones, but there was not a significant difference.

Table 3 Feature of planted ten clones.

clone No	1	21	31	39	45	18	29	40	49	54
Health	2	6	6	6	10	5	7	8	3	8
D (mm)	11.0	13.8	10.8	10.3	12.0	13.3	10.3	10.8	13.8	12.6
H (cm)	25	39	30	25	39	61	31	56	36	35

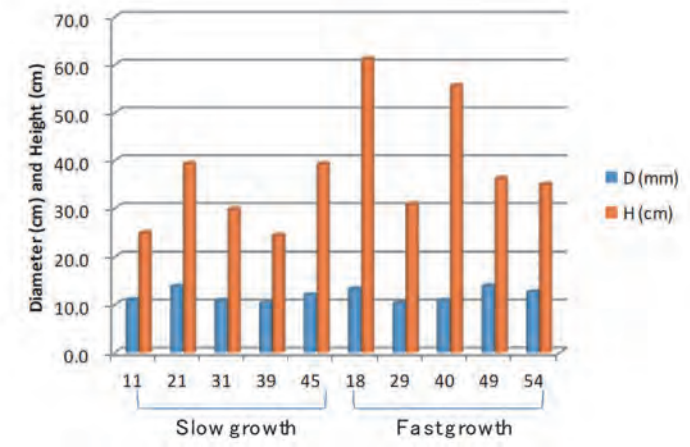


Fig.6 Tree height and diameter.

Photo A hole for replanting.

Appendix 5-2-3

Report of short term expert (Drought Tolerance)

Expertise	Name	Term
Drought Tolerance	Dr. Koichiro Gyokusen	10 ～24 Sep. 2018

1. Schedule

	AM	PM	Accommodation
09.10 (Mon.)		20:00 JAL330 Fukuoka-Haneda 21:40	
09.11 (Tue.)	00:30 EK313 Departure (TOKYO/HANEDA)	14:45 EK719 Arrival (NAIROBI)	**Nairobi**
09.12 (Wed.)	JICA (Lecture of safety) Nairobi to Kitui		Kitui
09.13 (Thr.)	Transfer from Kitui to Kibwezi Weather data collection at Kibwezi seed orchard		Kibwezi
09.14 (Fri)	Weather data collectiona at Kasigau and Voi		Kibwezi
09.15 (Sat)	Weather data collection at Ykituki and Makima Transfer from Kibwezi to Wmbu		Embu
09.16 (Sun.)	Weather data collection at Marimanti and Gaciongo Transfer from Embu to Kitui		Kitui
09.17 (Mon.)	Weather data collection at Tiva seed orchard		Kitui
09.18 (Tue.)	Measurement of Melia seedling at Kitui center nursery		Kitui
09.19 (Wed.)	Attachment of weather equipment at Kitui center		Kitui
09.20 (Thr.)	Chlorophyll measurement at Tiva seed orchard		Kitui
09.21 (Fri)	Measurement of dry weight of Melia seedling		Kitui
09.22 (Sat)	Data analysis		Kitui
09.23 (Sun.)	Travel to Nairobi (3hours)	16：40 **EK720** Nairobi-Dubai **22：40**	
09.24 (Mon.)	3:00 EK316 Dubai-Osaka 17:10	**19:35 NH1709** Osaka-Fukuoka 20:45	

2. Activities and results

2.1. Weather conditions at seed orchards and progeny test sites

[Activities]

Weather data at two seed orchards (Tiva and Kibwezi) and six progeny sites (Kasigau、Marimanti、Voi, Yikituki, Makima, and Gaciongo) were collected. Five data sets of radiation, temperature, moisture, precipitation and soil water potential were collected at two seed orchards. Three data sets of temperature, precipitation and soil water potential were collected at Kasigau と Marimanti, and two data sets of temperature and moisture were collected at Voi, Yikituki, Makima and Gaciongo, respectively. Data sets from Jan. 2018 to Sep. 2018 were collected this time.

[Results]

Weather data of two seed orchards were shown in fig.1. Soil water potential of Tiva was higher than that of Kibwezi.

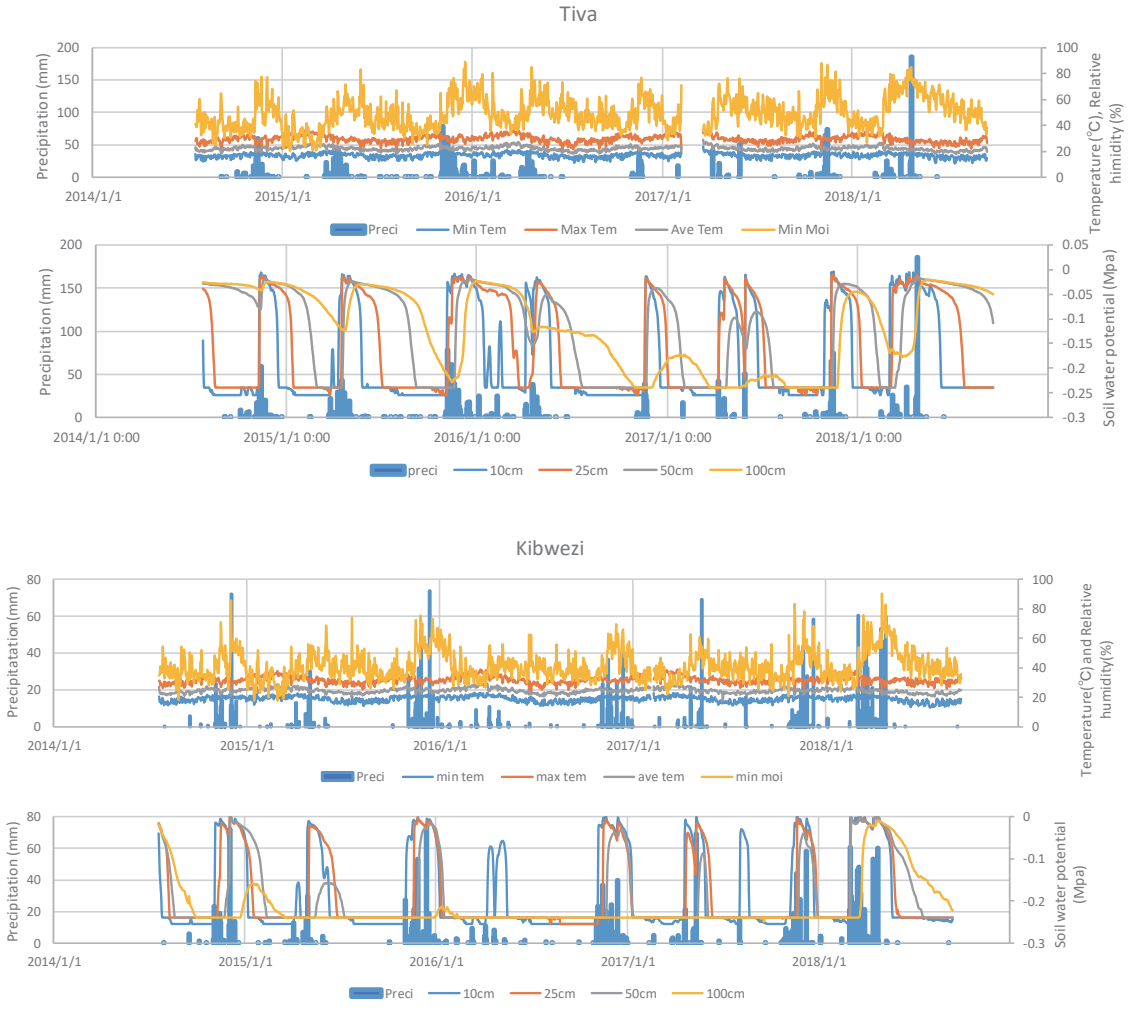


Fig.1 Weather condition in Tiva and Kibwezi seed orchards

Precipitations of Tiva, Kibwezi, Marimanti and Kasigau were shown in table 1. It was difficult to compare them directly because of a large fluctuation and missing values, but roughly speaking, precipitation of Marimanti was the highest and there was a little difference among three other sites. The precipitation of 2018 seemed to have a high trend compared with other years.

Precipitataion (mm)

2014	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva							0	0	2	24	226	10	
Kibwezi							0	0	6	3	79	124	
Marimanti													
Kasigau													

2015	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva	0	2	30	162	32	2	4	2	1	3	298	61	596
Kibwezi	0	2	4	58	46	1	0	0	0	1	199	130	441
Marimanti							0	1	0	113	677	101	
Kasigau							0	11	6	40	179	22	

2016	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva	37	35	1	181	3	2	0	0	0	0	139	0	398
Kibwezi	6	6	13	33	4	2	1	1	1	1	205	69	342
Marimant	5	1	5	179	92	24	0	0	1	3	167	44	521
Kasigau	14	7	15	124	2	11	4	20	8	1	64	41	310

2017	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva	18	(0)	(0)	71	59	0	0	0	4	17	187	2	359
Kibwezi	0	(5)	6	43	93	1	0	17	1	15	154	60	395
Marimant	1	6	1	93	84	1	0	0	1	74	177	4	441
Kasigau	0	5	232	19	85	9	0	5	52	26	(116)	(-)	550

2018	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva	0	7	49	273	3	0	0	0	0				333
Kibwezi	9	3	336	230	2	0	0	0	0				581
Marimant	0	0	119	404	89	10	6	0	0				628
Kasigau	0	15	210	61	9	9	1	8	30				344

No data Kibwezi (2018/2/4-2/7)
Tiva (2018/2/7-3/19)
Kacigau (2017/11/9-11/30, 2017/12/1-12/31)

The average monthly temperature was shown in table 2. We could get a full data set of temperature from Jan. 2016 to Sep. 2018. The monthly average temperature of Tiva, Kibwezi, Marimanti, Kasigau,Makima, Voi, Yikiytuki and Gashiongo were 22.3℃, 24.5℃, 28.2℃, 25.8℃, 22.9℃, 25.0℃, 23.5℃, 26,6℃, respectively. The monthly average temperature of Marimanti was the highest and that of Tivathe lowest.

Table 2 The monthly average temperature of two seed orchards and six progeny sites.

2014	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Tiva							20.9	21.3	21.4	23.4	22.3	22.1	21.9
Kibwezi							22.8	23.1	23.3	25.3	24.9	24.3	24.0
Marimanti													
Kasigau													
Makima													
Voi													
Ykituki													
Gashiongo													

2015	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Tiva	23.4	24.5	24.5	23.2	22.2	21.2	20.7	20.8	22.4	24.1	22.6	22.1	22.6
Kibwezi	25.7	26.6	26.5	26.1	24.5	23.6	22.7	22.8	24.1	25.9	25.0	24.4	24.8
Marimanti							27.0	27.7	29.5	30.1	25.8	26.5	27.8
Kasigau							23.6	23.1	24.4	25.8	26.0	27.8	25.1
Makima													
Voi													
Ykituki													
Gashiongo													

2016	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Tiva	22.7	23.4	25.6	23.8	21.7	20.9	20.1	20.7	21.0	23.4	22.7	22.4	22.4
Kibwezi	25.0	26.3	28.2	26.2	24.8	23.4	22.3	22.7	23.2	25.1	24.6	24.2	24.7
Marimanti	27.3	28.8	31.9	28.7	26.5	26.5	26.7	27.5	28.0	30.3	27.2	26.9	28.0
Kasigau	27.9	28.2	29.8	26.5	26.4	24.6	23.5	22.8	23.4	25.9	26.7	26.6	26.0
Makima		24.4	25.9	24.3	22.6	21.6	20.9	21.7	22.2	24.4	22.8	22.0	23.0
Voi		26.2	28.2	26.4	25.1	24.1	23.1	22.9	23.0	24.8	25.7	25.4	25.0
Ykituki		26.0	27.3	25.2	23.6	22.5	21.4	21.9	22.2	24.4	22.8	22.0	23.6
Gashiongo		27.1	29.3	27.8	26.2	26.2	25.6	26.3	26.0	27.7	25.4	24.9	26.6

2017	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Tiva	23.4	23.4	26.3	23.9	22.5	21.3	20.8	21.5	22.0	23.9	22.1	22.7	22.8
Kibwezi	25.6	(26.2)	27.8	26.4	24.3	23.5	22.9	23.2	24.0	25.7	24.2	24.9	24.8
Marimanti	28.1	29.4	31.8	28.9	27.1	28.5	27.9	28.5	29.2	29.8	26.6	28.2	28.7
Kasigau	28.5	27.9	28.7	27.8	24.8	24.9	24.0	24.0	24.2	25.7	25.5	26.8	26.1
Makima	22.9	24.4	26.2	24.0	23.0	22.3	21.9	22.7	23.1	24.7	22.2	22.7	23.3
Voi	26.4	26.1	27.7	27.1	25.2	24.5	23.6	23.5	23.9	25.5	25.2	25.4	25.3
Ykituki	22.9	25.2	26.8	25.4	23.3	22.9	22.1	22.6	23.1	25.0	23.2	24.4	23.9
Gashiongo	26.0	27.1	29.2	27.6	26.4	26.7	26.5	26.7	27.2	27.8	25.5	26.5	26.9

2018	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Tiva	23.6	24.4	22.4	21.6	21.4	20.1	19.8	20.3	21.7				21.7
Kibwezi	25.8	26.2	24.5	24.1	23.7	22.6	22.0	22.7	23.9				23.9
Marimanti	28.7	30.4	27.3	25.1	26.4	26.3	27.0	27.9	29.2				27.6
Kasigau	27.1	28.4	26.5	25.9	25.4	24.2	23.5	23.1	24.0				25.3
Makima	23.8	24.9	22.7	21.8	22.1	21.1	20.7	21.2	22.9				22.4
Voi	26.4	25.3	25.0	24.9	23.9	23.2	22.9	23.9	23.9				24.4
Ykituki	25.1	25.4	23.2	22.8	22.6	21.6	21.2	21.6	22.6				22.9
Gashiongo	26.8	27.9	25.8	24.4	26.0	25.7	25.9	26.5	27.5				26.3

No data： Kibwezi(2017/02/04-2017/02/07)

2.2. Weather equipment installation at Kitui center

There was already a weather station at Kitui Center, but data collection had not been conducted for the past few years because of the failure of equipment. Second hand weather loggers and new weather sensors were installed this time. New weather sensors were for precipitation, temperature and moisture measurement (photo 1).

Photo 1 Equipment installation of weather station at Kitui Center

2.3. Comparison of tree growth of 10 clones planted in Tiva seed orchard.

Grafted seedlings of ten clones were planted in Tiva seed orchard at Dec. 2017 to compare the tree growth and physiology. Ten clones were composed of five fast growth clones and five slow growth clones. Tree height, stem diameter at ground level, and chlorophyll contents (SPAD value) were measured this time.

Tree growth (H, D, D^2H) and chlorophyll were shown in table 2. Yellow color shows the slow growth clone and green color shows the fast clone, respectively. The growth of slow growth clone was lower than that of fast clones according to the result so far but there was not a relation between clone and SPAD value.

Table 2 Tree growth and SPAD value of ten clones

Clone no.	Tree No.	Lead attached No.	D^2H	sd	D	sd	H	sd	Chb	sd
	n	n	m^3		cm		cm		spad value	
39	7	6	0.00049	0.00045	17.5	2.2	80.1	12.6	50.9	3.6
31	6	5	0.00077	0.00075	19.7	4.9	93.5	11.6	49.0	6.0
1	5	3	0.00115	0.00083	14.7	3.9	78.0	38.9	50.8	6.8
21	5	3	0.00249	0.00226	18.3	6.9	96.2	49.3	49.3	3.5
54	9	2	0.00320	0.00261	19.8	5.3	115.8	38.2	43.3	7.2
29	5	4	0.00371	0.00342	24.2	10.0	106.0	40.1	57.7	4.2
49	5	4	0.00382	0.00461	21.0	7.9	108.8	59.8	47.5	10.2
45	8	7	0.00398	0.00258	23.0	3.8	125.5	32.7	46.0	3.2
40	8	5	0.00662	0.00852	25.1	10.2	124.0	73.0	51.1	10.5
18	6	4	0.00909	0.00794	26.3	10.5	159.3	60.9	54.7	9.9

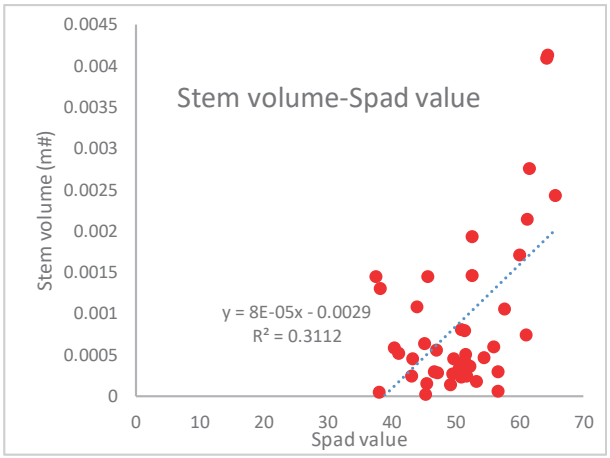


Fig. 2 The relationship between stem volume and SPD value

The relationship between stem volume and SPAD value was shown in Fig.2. There was a significant linear relation between stem volume and SPAD value.

2.4. Comparison of tree growth and some characteristics of fast and slow growth clones

Tree growth (H, D and H/D) and SPAD value of ten clones was shown in table 3. Seed of these clones were sown at May 2018 and composed of five fast growth clones and five slow growth clones. There was not a significant relation between tree growth (H and D) and SPAD value. However, there was a little difference in D and H, namely, D was bigger in fast growth clones and H was higher in slow growth clones (table 3). As a result, H/D of fast growth clone was bigger than that of slow growth clone (photo 2). There is a possibility that H/D of seedling becomes as a selection index of plus tree of *Melia volkensii.*

Clone No.	n	D	s.d.	H	s.d.	H/D	s.d.	SPAD value	s.d.
		mm		cm		mm/cm			
18	20	9.5	1.5	29.6	5.5	3.20	0.79	46.0	2.5
29	18	10.5	1.5	34.2	6.7	3.28	0.63	43.7	4.3
40	28	11.3	1.9	33.1	5.8	2.99	0.68	46.3	3.9
45	12	9.5	0.7	31.3	5.2	3.32	0.60	44.7	2.8
49	22	10.6	1.5	35.2	5.3	3.37	0.57	44.8	3.0
1	21	9.4	1.4	34.8	11.5	3.76	1.45	47.2	4.0
21	22	9.1	1.2	37.5	6.2	4.19	0.79	46.9	4.9
31	20	8.7	0.7	35.5	5.4	4.12	0.75	46.2	4.6
39	22	9.2	1.1	35.0	5.5	3.84	0.70	43.4	3.9
54	19	8.9	1.0	30.7	7.3	3.49	0.91	46.1	3.9

Table 3 Comparison of tree growth of ten clones

Photo 2 The fast growth clone (No.40) and slow growth clone (No.1)

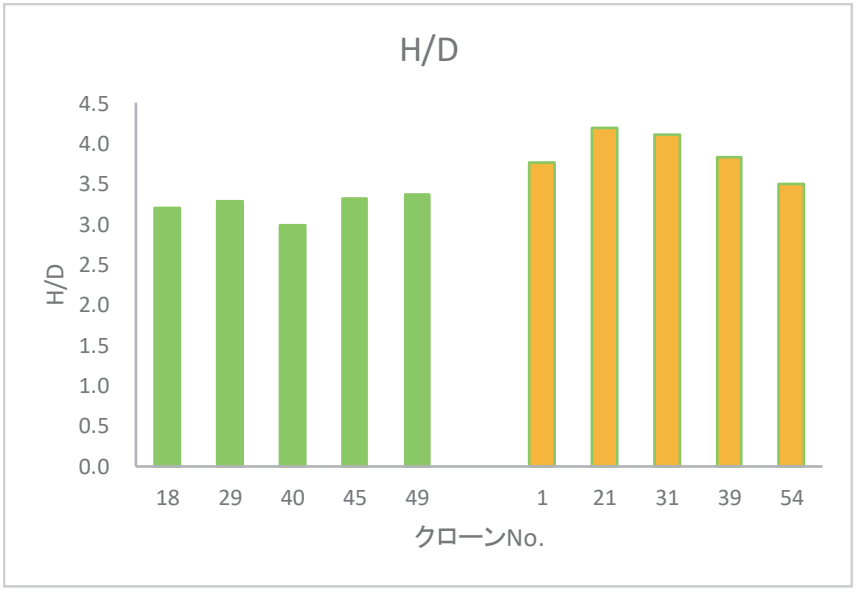


Fig.3 H/D value of the fast and slow growth clone

Appendix 5-2-4

Report of short term expert (Drought Tolerance)

Expertise	Name	Term
Drought Tolerance	Dr. Eiji Goto	16 ～24 Sep. 2018

○ Schedule

	AM	PM	Accommodation
09.16 (Sun.)		Fukuoka- Haneda	
09.17 (Mon.)	Haneda- Dubai- Nairobi Transfer from Nairobi airport to Kitui		Kitui
09.18 (Tue.)	Maintenance of Li-6400	Preparation of drought tolerance test	Kitui
09.19 (Wed.)	Measurement of drought tolerance	Measurement of photosynthetic performance	Kitui
09.20 (Thr.)	Measurement of drought tolerance	Measurement of photosynthetic performance	Kitui
09.21 (Fri.)	Measurement of drought tolerance	Measurement of photosynthetic performance	Kitui
09.22 (Sat.)	Measurement of drought tolerance	Measurement of photosynthetic performance	Kitui
09.23 (Sun.)	Transfer from Kitui to Nairobi airport. Nairobi- Dubai		
09.24 (Mon.)	Dubai- Osaka- Fukuoka		

○Achievement

①Maintenance of Gas exchanege equipment (Li-6400)

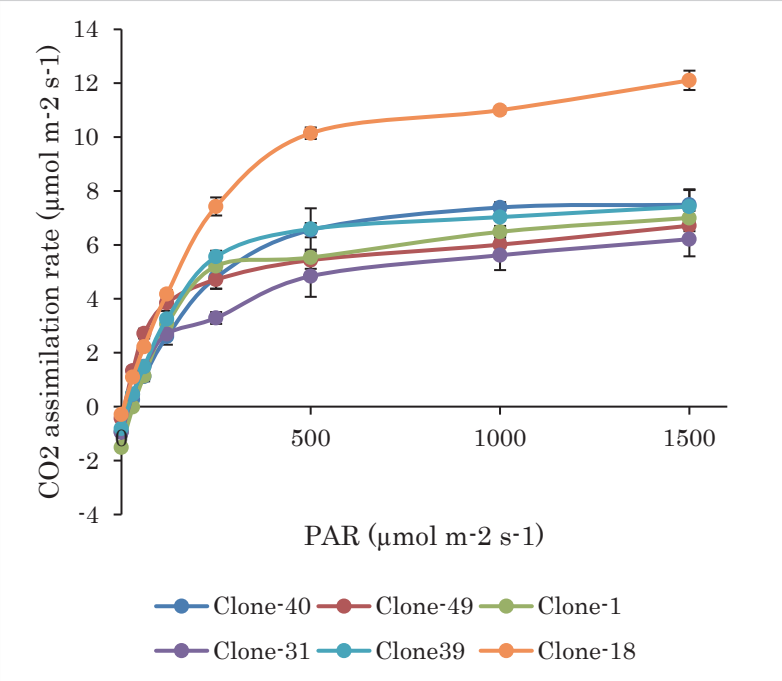
The condition of the gas exchange measuring apparatus (Li-6400; manufactured by Licor) used for the measurement of the photosynthetic activity was tested. No abnormality was found in air leakage and impaired light intensity. However, since

internal calibration is necessary, I recommend to send the manufacture for detail calibration if possible.

②Photosynthetic capacity of candidate for dry tolerance-resistant tolerance

I. Comparison of the photosynthetic capacity

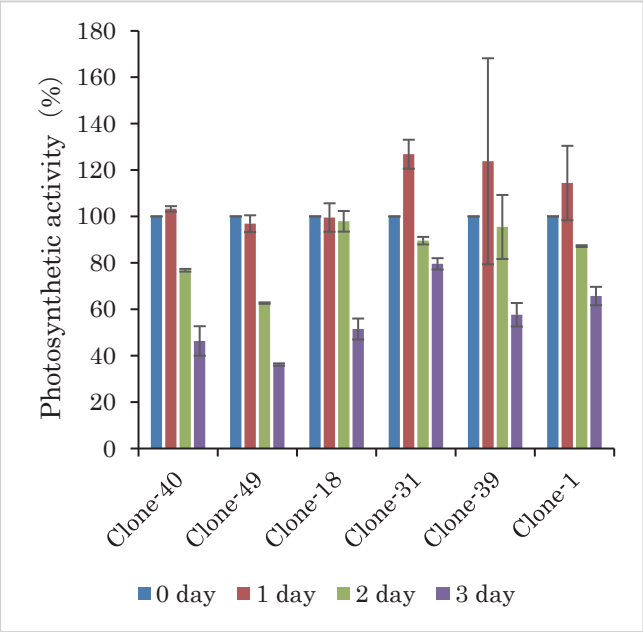
Using the leaves of the superior candidate lines (line No. 40, 49, 18) and the inferior candidate lines (line No. 39, 31, 1) in the test forests of Tiva and Kibwezi (about 6 months after sowing), light - dependent photosynthetic activity (fixed rate of CO 2) was measured together with the counterpart. As a result, it was found that the photosynthetic rate of No. 18 line is higher than that of the other lines (Fig. 1). On the other hand, two superior candidate No. 40 and No. 49 lines had photosynthetic rates comparable to those of inferior lines. This measurement is a measurement at a specific time and it is necessary to repeat same analysis.



Ⅱ Comparison of drought stress

The superior candidate lines (line No. 40, 49, 18) and the inferior candidate lines (line No. 39, 31, 1) were investigated the resistance to drought stress. Three lines of each line size were prepared and divided into a treatment group with or without watering, the maximum photosynthetic rate was measured. At the same time, we also investigated the degree of soil moisture.

As a result, soil moisture decreased with the number of days in the drought stress. Furthermore, comparing the photosynthetic capacity at that time, the photosynthetic performance was decreased by drought stress. Interestingly, No. 31 (inferior line) was found to maintain high even under extreme drying conditions.



The value of the maximum photosynthesis rate before the treatment without watering was taken as 100%. The number of days indicates the number of days of drought stress treatment.

Appendix 5-2-5

Report of short term expert (Drought Tolerance)

Expertise	Name	Term
Drought Tolerance	Dr. Koichiro Gyokusen	9 ～23 Sep. 2019

1. Schedule

	AM	PM	Accommodation
09.9 (Mon.)		20:00 JAL326 Fukuoka-Haneda	
09.10 (Tue.)	00:30 EK313 Departure (TOKYO/HANEDA)	14:45 EK719 Arrival (NAIROBI) Move to Kitui	Kitui
09.11 (Wed.)	Kitui-Kibwezi Collecting weather data (Kibwezi)		Kibwezi
09.12 (Thr.)	Collecting weather data (Kasigau, Voi))		Kibwezi
09.13 (Fri.)	Collecting weather data (Ykituki,Makima) Move to Embu		Embu
09.14 (Sat.)	Collecting weather data (Marimanti,Gaciongo) Move to Kitui		Kitui
09.15(Sun.)	Data analysis		Kitui
09.16 (Mon.)	Collecting weather data (Tiva) Measurement of Melia gwoeth at Tiva		Kitui
09.17 (Tue.)	Study on seedlings in nursery (Kitui center)		Kitui
09.18 (Wed.)	Reoair of weather station at Tiva seed orchard Study on seedlings in nursery (Kitui center)		Kitui
09.19 (Thr.)	Study on seedlings in nursery (Kitui center)		Kitui
09.20 (Fri.)	Study on seedlings in nursery (Kitui center)		Kitui
09.21 (Sat.)	Travel to Nairobi (3hours)	16:40 EK720 Nairobi-Dubai 22:40	
09.22(Sun.)	3:00 EK316 Dubai-Osaka 17:10	Osaka-Fukuoka JR	
09.23 (Mon.)	Osaka-Fukuoka JR		

2. Activities and results

2.1. Weather conditions at seed orchards and progeny test sites

[Activities]

Weather data at two seed orchards (Tiva and Kibwezi) and six progeny sites (Kasigau、Marimanti、Voi, Yikituki, Makima, and Gaciongo) were collected. Five data sets of radiation, temperature, moisture, precipitation, and soil water potential were collected at two seed orchards. Three data sets of temperature, precipitation, and soil water potential were collected at Kasigau と Marimanti, and two data sets of temperature and moisture were collected at Voi, Yikituki, Makima and Gaciongo, respectively. Data sets from Sep. 2018 to Sep. 2019 was collected this time.

[Results]

Weather data of two seed orchards were shown in fig.1. Soil water potential of Tiva was higher than that of Kibwezi. Precipitation data in Tiva has not been collected in a year because the tipping bucket rain gauge was hampered by a beehive.

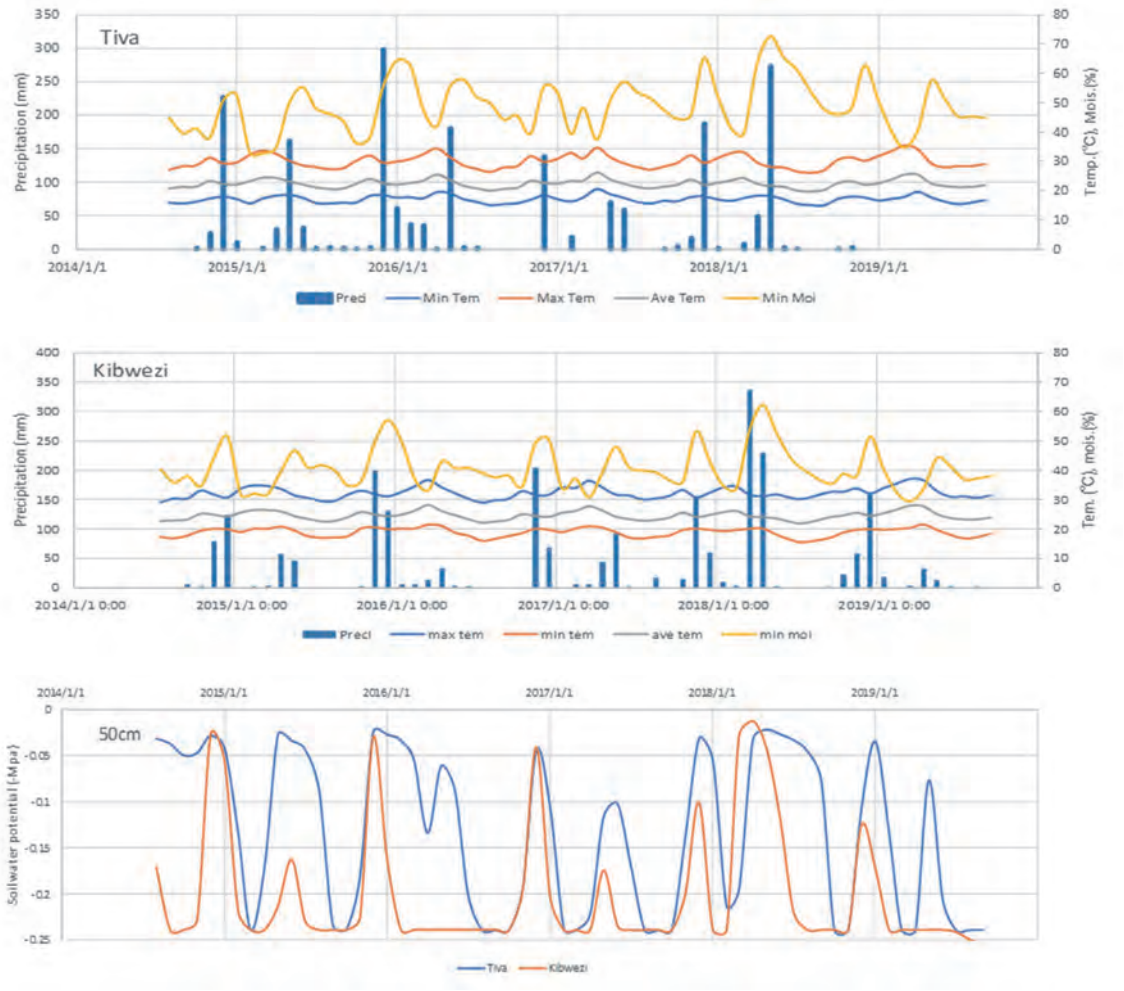


Fig.1 Weather condition and Soil water potential in Tiva and Kibwezi seed orchards

Precipitation data in Tiva were not collected, however, in light of some aspects such as changing soil water potential, lowest moisture, etc., the year 2019 was seemed drier than 2018. Table 1 shows the monthly average temperature of two seed orchards and six progeny sites. The average temperature was used the three years average between Feb. 2016 to Jan. 2019. From the lowest temperature, the order is Tiva, Makima, Yikituki, Kibwezi, Voi, Kasigau, Gaciongo, Marimanti. Tiva was 22.4℃, Marimanti was 28.2℃, the gap between them was 5.8℃.

Besides, weather data in each site can be shown in Annex 1, 2.

Table 1 The monthly average temperature of two seed orchards and six progeny sites.

Month	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Tiva	23.2	23.7	24.7	23.1	21.9	20.8	20.2	20.8	21.7	23.3	22.7	22.4	22.4
Makima	23.3	24.6	24.9	23.4	22.6	21.7	21.2	21.9	22.9	24.3	22.9	22.4	23.0
Yikituki	24.3	25.6	25.8	24.5	23.2	22.3	21.6	22.0	22.8	24.4	23.5	23.3	23.6
Kibwezi	25.6	26.3	26.8	25.5	24.3	23.2	22.4	22.9	23.8	25.2	24.8	24.6	24.6
Voi	26.2	25.9	27.0	26.1	24.7	24.0	23.2	23.4	23.6	25.0	25.4	25.3	25.0
Kasigau	28.1	28.2	28.3	26.7	25.5	24.6	23.7	23.3	23.9	25.6	26.2	26.8	25.9
Gaciongo	26.7	27.4	28.1	26.6	26.2	26.2	26.0	26.5	27.1	28.0	26.0	25.7	26.7
Marimanti	28.3	29.5	30.3	27.6	26.7	27.1	27.2	28.0	29.0	30.2	27.3	27.0	28.2
Ave.	25.7	26.4	27.0	25.4	24.4	23.7	23.2	23.6	24.3	25.8	24.9	24.7	24.9

2016.2～2019.1

2.2 Comparison of tree growth and some characteristics of fast and slow growth clones.

In order to reconfirm and to clarify the reason for the growth difference, the planting testing site was established in Dec. 2017. In this time we have checked the height and diameter of those trees. Tree growth is different by planting position, the two-lane adjoining to seed orchard did not find its growth due to water conflict with adjoining trees.

Photo 1　Tree growth in the test site（L：center、R：adjoining to seed orchard）

In this site, there are many factors (not enough rooting, late weeding, and conflict with adjoining trees) that may lead to a slower growth rate. Given the situation, not directly compare the growth rate, but contrast the individual numbers and number of crones

among the 20 best growth trees. As a consequence, selected clones as a rapid growth one were included in 14 trees (70%) in terms of height and root diameter（Table 2）. Also, all the clones were included.

In these circumstances, we confirmed the superiority of the crones of "rapid growth tree", and its genetical characteristics.

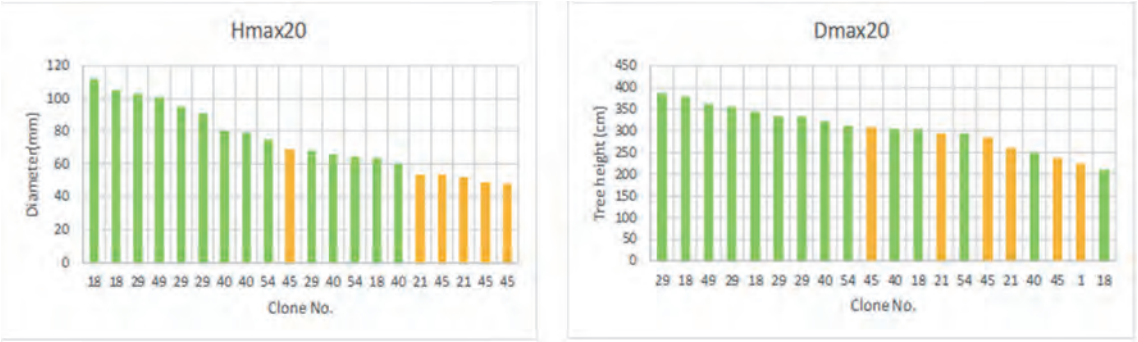


Table 2 Name of the best 20 clones and their size

2.3. Comparison of seedling growth of fast and slow growth clones

As a result of the comparison of the seedling last year, we found that H/D of fast growth clone was bigger than that of slow growth clone. There is a possibility that H/D of seedling becomes a selection index of plus tree of *Melia volkensii.* In this time we compared 20 clone seedlings which were sown in May 2019. Also checked the form of 16 clone seedlings that were collected in 2016.

Tree growth (H, D, and H/D) and SPAD value in 2016 and 2019 were shown in table 2, 3. Figure 3 shows the relation between the rank in D2H (2014) and in H/D ratio(2016, 2019). A positive correlation can be found in both year (2016: r=0.679**, 2019: r=0.532*)、lower H/D clone tend to more widespread growth. These outcomes would support the result of 2018, namely, D was bigger in fast-growth clones and H was higher in slow growth clones. However, clones 36 and 19 showed lower H/D in spite of lower growth in 2019. It is assumed that both seeds would be hybrid with higher growth clone.

The possible reason for the correlation between H/D and growth is that H/D shows the difference in distribution style. Therefore, we are going to continue the research; ex. The difference distribution to above-ground level and Assimilatory to Non-assimilatory Organ. Also, additional investigation, more clones, growth test after planting, is needed.

	clone no	n	Height	s.d.	Diameter	s.d.	h/d	s.d.	Rank in growth
1	44	8	20.3	1.1	9.7	3.5	2.1	0.5	1
2	27	10	28.5	1.8	10.1	1.8	2.9	0.5	6
3	18	10	31.9	0.5	10.1	4.7	3.1	0.4	4
4	36	10	32.4	1.5	10.2	3.8	3.3	0.7	15
5	49	10	31.4	0.8	9.4	3.9	3.3	0.4	3
6	19	10	32.3	0.9	9.4	2.9	3.4	0.3	18
7	29	10	36.2	0.9	10.5	5.0	3.5	0.6	2
8	14	10	35.3	1.1	10.2	3.9	3.5	0.6	8
9	6	10	32.3	1.3	9.4	4.8	3.5	0.7	5
10	22	10	32.4	0.8	9.2	2.8	3.6	0.5	9
11	11	10	34.4	0.8	9.7	2.6	3.6	0.4	13
12	52	10	31.2	0.6	8.1	3.1	3.9	0.2	7
13	38	10	36.2	0.8	9.4	3.4	3.9	0.3	16
14	41	10	34.8	0.8	9.0	4.4	3.9	0.5	14
15	67	10	35.2	0.9	8.9	3.4	4.0	0.5	
16	55	10	39.0	0.7	9.2	6.4	4.3	0.7	17
17	39	10	38.1	0.8	8.7	3.3	4.4	0.4	19
18	3	10	42.1	0.7	8.7	2.3	4.9	0.5	12
19	53	10	46.2	0.9	9.0	4.2	5.2	0.8	11
20	32	10	44.5	0.9	8.4	2.9	5.4	0.7	10

Table 2 Comparison of D/H ratio of 20 clones (2019)

	Clone No	n	Height	s.d.	Diameter	s.d.	H/D	s.d.	Rank in growth
1	49	20	21.9	4.4	9.3	1.4	2.3	0.6	2
2	8	6	25.3	5.4	9.4	1.1	2.7	0.5	4
3	59	21	29.3	5.8	10.4	1.2	2.8	0.7	5
4	29	21	30.3	6.1	10.4	1.2	2.9	0.7	1
5	57	9	26.9	4.8	9.1	1.8	3.0	0.7	10
6	54	18	25.5	3.9	8.4	1.3	3.0	0.6	13
7	18	21	29.6	6.1	9.6	1.0	3.1	0.7	3
8	12	21	29.2	5.1	9.2	1.3	3.2	0.8	6
9	21	21	30.5	6.2	9.4	1.1	3.2	0.8	15
10	24	16	29.4	4.6	9.1	1.0	3.2	0.6	7
11	32	17	26.9	4.5	8.2	1.1	3.3	0.8	8
12	39	15	28.6	3.7	8.6	1.5	3.3	0.7	12
13	19	17	28.7	5.8	8.3	1.0	3.4	1.0	14
14	46	21	32.9	7.1	9.0	1.8	3.6	1.1	9
15	1	20	30.3	4.7	8.1	0.9	3.7	0.6	16
16	33	15	29.7	4.8	7.9	0.7	3.8	0.7	11

fast growth middle growth slow growt

Table 3 Comparison of D/H ratio of 16 clones (2016)

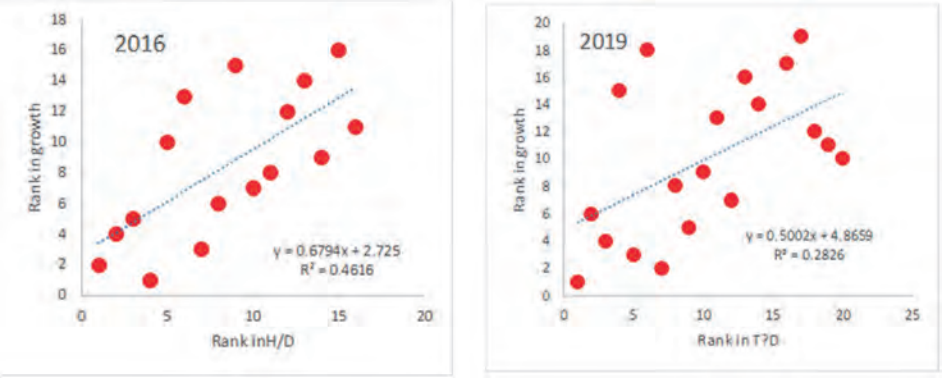


Fig.3 H/D value of the fast and slow growth clone (2016, 2019)

Annex 1：Monthly average temperature in PTSs (2014-2019)

2014	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Tiva							20.9	21.3	21.4	23.4	22.3	22.1	21.9
Kibwezi							22.8	23.1	23.3	25.3	24.9	24.3	24.0
Marimanti													
Kasigau													
Makina													
Voi													
Ykituki													
Gashongo													

2015	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Tiva	23.4	24.5	24.5	23.2	22.2	21.2	20.7	20.8	22.4	24.1	22.6	22.1	22.6
Kibwezi	25.7	26.6	26.5	26.1	24.5	23.6	22.7	22.8	24.1	25.9	25.0	24.4	24.8
Marimanti							27.0	27.7	29.5	30.1	25.8	26.5	27.8
Kasigau							23.6	23.1	24.4	25.8	26.0	27.8	25.1
Makina													
Voi													
Ykituki													
Gashongo													

2016	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Tiva	22.7	23.4	25.6	23.8	21.7	20.9	20.1	20.7	21.0	23.4	22.7	22.4	22.4
Kibwezi	25.0	26.3	28.2	26.2	24.8	23.4	22.3	22.7	23.2	25.1	24.6	24.2	24.7
Marimanti	27.3	28.8	31.9	28.7	26.5	26.5	26.7	27.5	28.0	30.3	27.2	26.9	28.0
Kasigau	27.9	28.2	29.8	26.5	26.4	24.6	23.5	22.8	23.4	25.9	26.7	26.6	26.0
Makina		24.4	25.9	24.3	22.6	21.6	20.9	21.7	22.2	24.4	22.8	22.0	23.0
Voi		26.2	28.2	26.4	25.1	24.1	23.1	22.9	23.0	24.8	25.7	25.4	25.0
Ykituki		26.0	27.3	25.2	23.6	22.5	21.4	21.9	22.2	24.4	22.8	22.0	23.6
Gashongo		27.1	29.3	27.8	26.2	26.2	25.6	26.3	26.0	27.7	25.4	24.9	26.6

2017	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Tiva	23.4	23.4	26.3	23.9	22.5	21.3	20.8	21.5	22.0	23.9	22.1	22.7	22.8
Kibwezi	25.6	(26.2)	27.8	26.4	24.3	23.5	22.9	23.2	24.0	25.7	24.2	24.9	24.8
Marimanti	28.1	29.4	31.8	28.9	27.1	28.5	27.9	28.5	29.2	29.8	26.6	28.2	28.7
Kasigau	28.5	27.9	28.7	27.8	24.8	24.9	24.0	24.0	24.2	25.7	25.5	26.8	26.1
Makina	22.9	24.4	26.2	24.0	23.0	22.3	21.9	22.7	23.1	24.7	22.2	22.7	23.3
Voi	26.4	26.1	27.7	27.1	25.2	24.5	23.6	23.5	23.9	25.5	25.2	25.4	25.3
Ykituki	22.9	25.2	26.8	25.4	23.3	22.9	22.1	22.6	23.1	25.0	23.2	24.4	23.9
Gaciongo	26.0	27.1	29.2	27.6	26.4	26.7	26.5	26.7	27.2	27.8	25.5	26.5	26.9

2018	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Tiva	23.6	24.4	22.4	21.6	21.4	20.1	19.8	20.3	22.1	22.7	23.3	22.1	22.0
Kibwezi	25.8	26.2	24.5	24.1	23.7	22.6	22.0	22.7	24.1	24.7	25.6	24.6	24.2
Marimanti	28.7	30.4	27.3	25.1	26.4	26.3	27.0	27.9	29.8	30.4	28.2	25.9	27.8
Kasigau	27.1	28.4	26.5	25.9	25.4	24.2	23.5	23.1	24.2	25.3	26.5	27.1	25.6
Makina	23.8	24.9	22.7	21.8	22.1	21.1	20.7	21.2	23.2	23.9	23.7	22.5	22.6
Voi	26.4	25.3	25.0	24.9	23.9	23.2	22.9	23.9	24.0	24.7	25.4	25.3	24.6
Ykituki	25.1	25.4	23.2	22.8	22.6	21.6	21.2	21.6	23.2	23.7	24.7	23.5	23.2
Gaciongo	26.8	27.9	25.8	24.4	26.0	25.7	25.9	26.5	27.9	28.5	27.2	25.8	26.5

2019	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
Tiva	22.6	23.9	25.5	25.5	22.5	21.6	21.2	21.3	22.0				
Kibwezi	25.4	26.7	28.1	27.8	25.1	23.8	23.4	23.4	24.0				
Marimanti	28.1	31.0	31.8	31.4	29.8	29.1	28.7	28.6	29.0				
Kasigau	28.5	28.6	30.1	28.7	24.9	25.1	24.6	24.0	24.1				
Makina	23.2	24.8	26.2	25.5	23.7	22.3	22.3	22.7	22.7				
Voi	25.9	26.7	27.7	27.7	24.9	24.3	23.8	23.6	23.9				
Ykituki	24.7	25.7	27.1	26.6	24.2	22.9	22.5	22.5	22.9				
Gaciongo	27.2	28.2	29.2	29.5	28.1	26.9	26.6	26.7	27.2				

No data： Kibwezi (2017/02/04-2017/02/07)

Annex 2 : Monthly precipitation in PTSs (2014-2019)

2014	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva							0	0	2	24	226	10	
Kbwezi							0	0	6	3	79	124	
Marimanti													
Kasigau													

2015	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva	0	2	30	162	32	2	4	2	1	3	298	61	596
Kbwezi	0	2	4	58	46	1	0	0	0	1	199	130	441
Marimanti							0	1	0	113	677	101	
Kasigau							0	11	6	40	179	22	

2016	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva	37	35	1	181	3	2	0	0	0	0	139	0	398
Kbwezi	6	6	13	33	4	2	1	1	1	1	205	69	342
Marimant	5	1	5	179	92	24	0	0	1	3	167	44	521
Kasigau	14	7	15	124	2	11	4	20	8	1	64	41	310

2017	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva	18	(0)	(0)	71	59	0	0	0	4	17	187	2	359
Kbwezi	0	(5)	6	43	93	1	0	17	1	15	154	60	395
Marimant	1	6	1	93	84	1	0	0	1	74	177	4	441
Kasigau	0	5	232	19	85	9	0	5	52	26	(116)	(-)	550

2018	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva	0	7	49	273	3	0	0	0	(0)	(0)	(4)	-	333
Kbwezi	9	3	336	230	2	0	0	0	2	22	59	159	822
Marimant	0	0	119	404	89	10	6	0	1	4	69	154	857
Kasigau	0	15	210	61	9	9	1	8	40	106	41	92	592

2019	1	2	3	4	5	6	7	8	9	10	11	12	Total
Tiva	-	-	-	-	-	-	-	-	-				0
Kbwezi	18	1	3	32	13	2	0	2	0				70
Marimant	32	3	15	59	11	9	0	6	0				134
Kasigau	21	32	21	84	50	1	1	24	7				241

No data Kbwezi(2018/2/4-2/7)
Tiva (2018/2/7-3/19),(2018/8/18-2019/8/18)
Kacigau (2017/11/8-11/30,2017/12/1-12/31)

Appendix 5-2-6

Report of short term expert (Drought Tolerance)

Expertise	Name	Term
Drought Tolerance	Dr. Koichiro Gyokusen	16～29 Feb. 2020

1.Schedule

	AM	PM	Accommodation
02.16 (Sun.)		20:00 JAL330 Fukuoka-Haneda 21:35	
02.17 (Mon.)	00:30 EK313 07:20 Departure (TOKYO/HANEDA)	10:25 EK719 14:35 Arrival (NAIROBI) Move to Kitui	Kitui
02.18 (Tue.)	Kitui-Kibwezi Collecting weather data (Kibwezi) Survey of Melia stand		Kibwezi
02.19 (Wed.)	Collecting weather data (Kasigau, Voi)		Kibwezi
02.20 (Thr.)	Collecting weather data (Yikituki,Makima) Move to Embu		Embu
02.21 (Fri.)	Collecting weather data (Marimanti,Gaciongo) Move to Kitui		Kitui
02.22 (Sat.)	Study on seedlings in nursery (Kitui center)		Kitui
02.23 (Sun.)	Study on seedlings in nursery (Kitui center)		Kitui
02.24 (Mon.)	Study on seedlings in nursery (Kitui center)		Kitui
02.25 (Tue.)	Collecting weather data (Tiva) Measurement of Melia growth at Tiva		Kitui
02.26 (Wed.)	Survey of Melia stand at Tiva		Kitui
02.27 (Thr.)	Survey of Melia stand at Tiva		Kitui
02.28 (Fri.)	Travel to Nairobi (3hours)	16:50 EK720 Nairobi-Dubai 22:50	
02.29 (Sat.)	3:05 EK316 Dubai-Osaka 17:05	20:10 NH1709 Osaka-Fukuoka 21:25	

2. Activities and Results

2.1. Weather conditions in seed orchards and progeny test sites

[Activity]

We downloaded the weather data collected by data logger in 8 sites, namely, two sites of seed orchard in Tiva and Kibwezi, and six sites of progeny site in Kasigau、Marimanti, Voi, Yikituki, Makima, and Gaciongo. Five weather items, i.e. solar radiation, temperature, moisture, precipitation and soil water potential were collected in two seed orchards. Four weather items, i.e. temperature, moisture, precipitation and soil water potential were collected in Kasigau and Marimanti. Two weather items, i.e. temperature and moisture were collected in Voi, Yikituki, Makima, Gaciongo. This time we downloaded the data from Sep. 2029 to Fe. 2020.

[Rseult]

There was a lot of rain fall during those days, and the meteorological observatory of Kenya said the rain was an event happened once in several decades. Then the soil water content was high and Melia tees could keep their leaves on it. The changes of temperature, precipitation and soil water potential of Marimanti was shown in fig.1.2. There were three records of over 100mm precipitation at Marimanti and there were many rainy days.

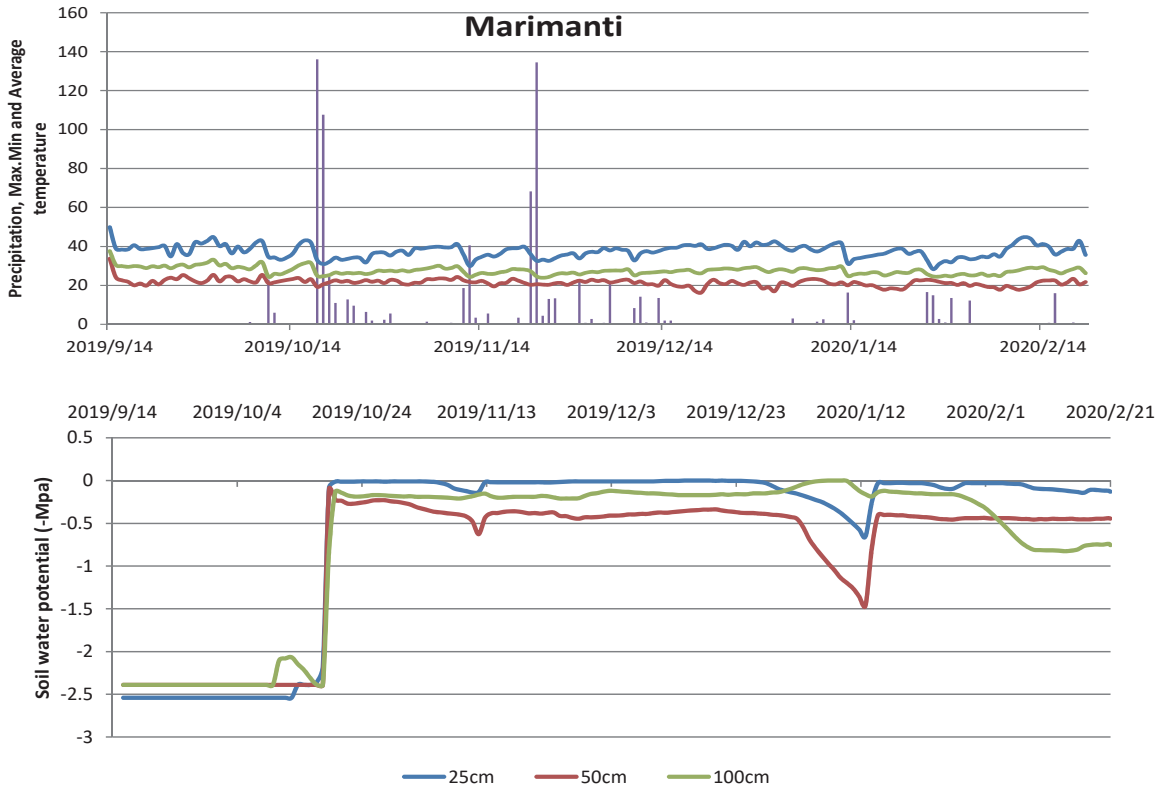


Fig.1,2 Changes of precipitation, temperature and soil water in Marimanti

2.2. The growth of Melia clone at 7 years after planting in two seed orchards.

[Activity]

Tiva seed orchard was established in Oct.-Nov. 2012 and Kibwezi seed orchard was established in Feb. 2013. The measurement of tree size of planted tree was conducted in Jul.2013 and May 2014, respectively. This time, we conducted the third time measurement of seven years old trees in Nov. 2019 and analyzed the data. The dada used in this analysis was averaged of each clone in spite of irregular data size.

[Result]

The stem volume (D_2H) put it from largest to smallest of Tiva and Kibwezi was shown in fig.3 and fig. 4., and the comparison of stem volume of two sites was shown in fig.5. There was a significant positive correlation between the volume of Tiva and Kibwezi (fig.5). We can say that the fast growth clone can grow fast in different site and vice versa. Especially, the growth of clone49 and clone18 was splendid. There was also a significant positive correlation between stem volume of 2 years and 7 years old tree (fig.6). This result suggests that we can select the superior tree in young stage.

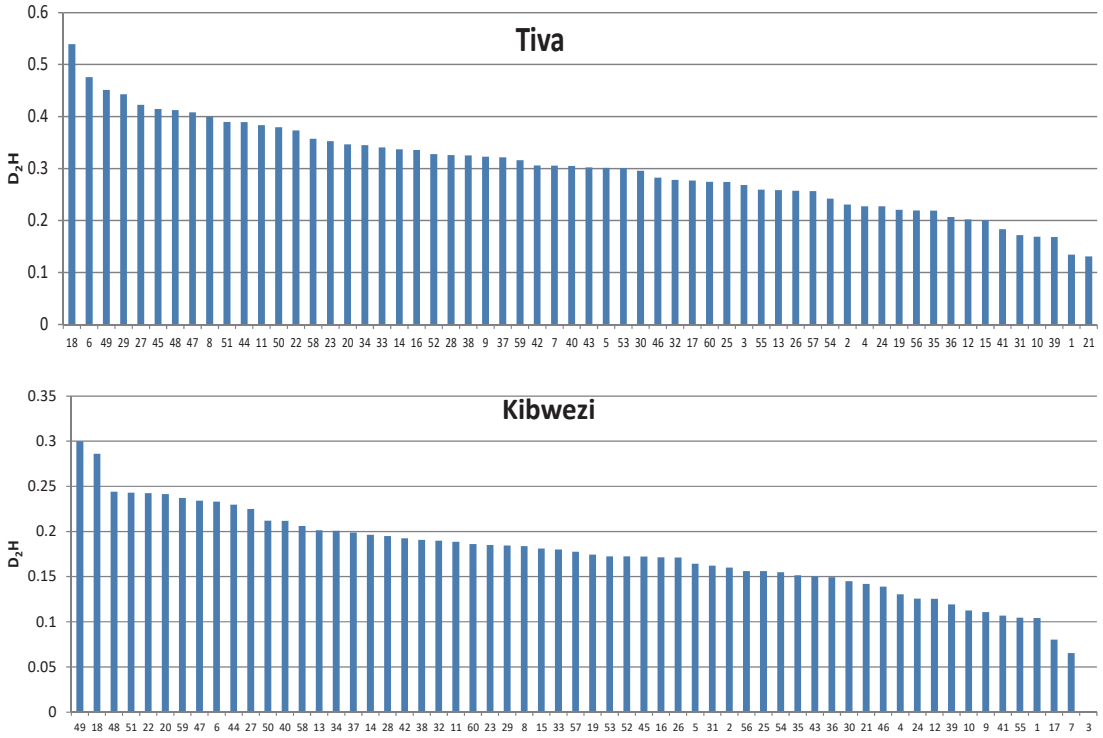


Fig.3, 4 Stem volume of each clone in Tiva and Kibwezi orchard

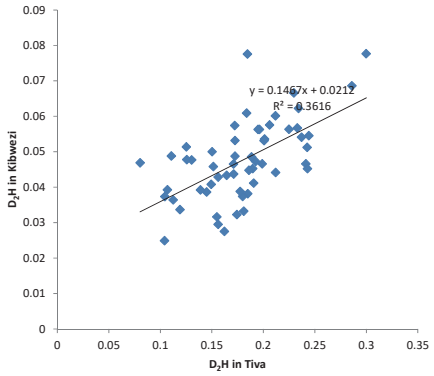


Fig.5 Comparison of stem volume between Tiva and Kibwezi orchard.

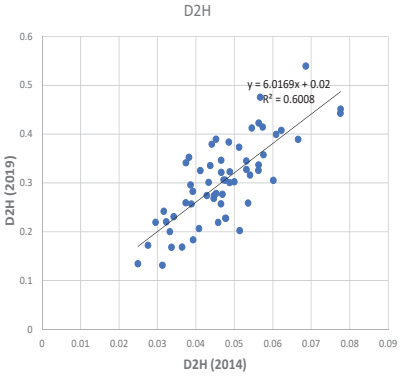


Fig.6 Comparison of stem volume between 7 years and 2 years in Tuva orchard.

Appendix 5-2-7

(Internal work report)

Expertise	Name	Term
Drought Tolerance	Dr. Koichiro Gyokusen	Aug. 2021

(4-1-1) Development and application of drought tolerance indices related to the growth of Melia (Kyushu university, Gyokusen)

1. Comparison of the growth pattern of superior and inferior clone (fig.1)

Stem volume growth of plus trees planted at Tiva and Kibwezi seed orchards was compared. The superior clone could continue its growth under water stress, and the stem shrinkage of superior clone under severe water stress was smaller than that of inferior clone. This result suggests that superior clone has some physiological features to reduce the effect of water stress. Physiological parameters related to water stress might be indexes for plus tree selection of *Melia*.

Figure 1 Seasonal stem growth pattern of superior and inferior clones.
The measurement was conducted in Tiva (upper figure) and Kibwezi (lower figure) seed orchards. Superior clone was averaged of 11 individual trees (4 clones) and inferior clone was averaged of 9 individual trees (3 clones), respectively.

2. Comparison of the stem volume growth of plus trees planted at Tiva and Kibwezi seed orchards (fig.2).

There was a significant positive correlation between the volume in Tiva and KIbwezi. This result suggests that the selected superior or inferior clone has a genetically high or low growth ability.

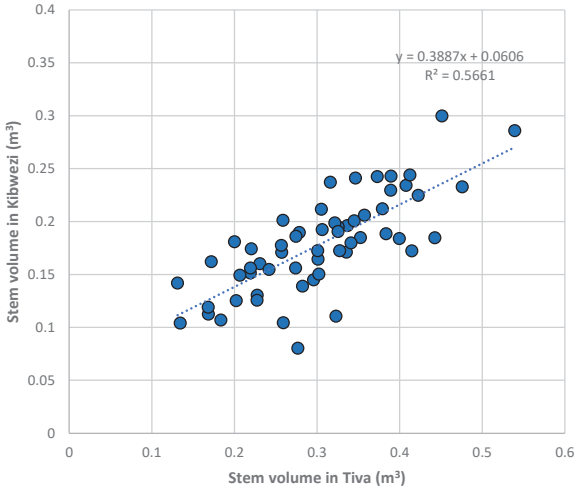


Figure 2 The comparison of stem volume between Kibwezi and Tiva seed orchards.
Dots indicated the average of each clone.

3. Correlation between 2 years and 7 years stem volume in two seed orchards (fig.3)

There was a significant positive correlation between stem volume of 2 years and 7 years old. This result suggests that we can select the superior clone in young stage.

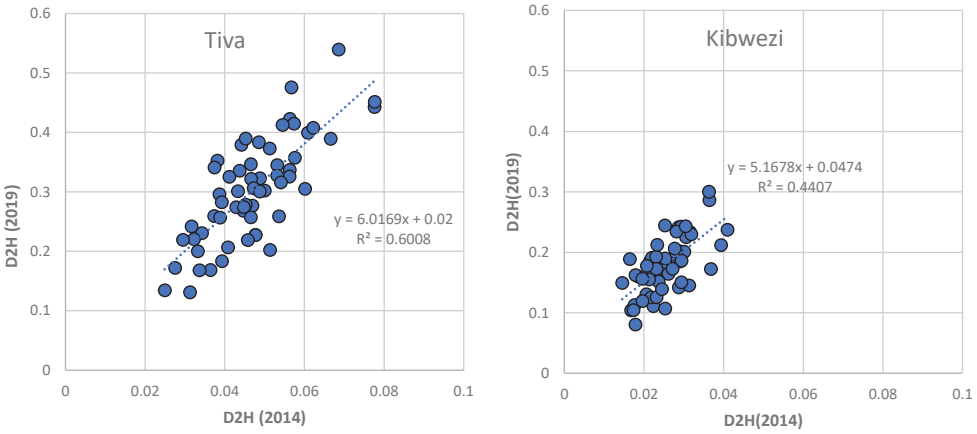


Figure 3 The comparison of stem volume between 2 and 7 years in Tiva and Kibwezi seed orchards.
A dot indicated the average of each clone. Left figure showed Tiva seed orchard and left figure indicates Kibwezi seed orchard, respectively.

4. Morphological characteristics of *Melia* seedling grown from open seed of superior and inferior clone (fig.4).

Tree height (H) of superior clone was a little lower than that of inferior clone and the stem diameter (D) of superior clone was a little larger than that of inferior clone. As a result, the H/D ratio of superior clone was smaller than that of inferior clone. Seedlings from 36 clones were compared, and the H/D of superior clone was smaller than that of inferior clones. There is a possibility that H/D ratio of seedling is an available index for selecting the *Melia* plus tree.

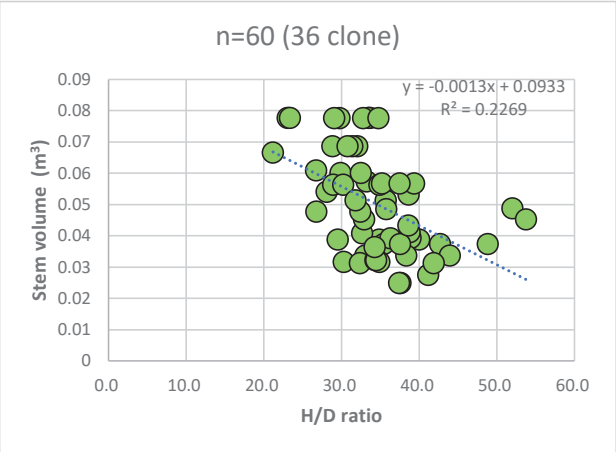


Figure 4 The relationship between stem volume of each clone and H/D ratio of each seedling .
The stem volume was obtained at Tiva orchard after two years of planting .
The data of H/D were obtained with four times of experiments at Kitui nursery.
Each dot was obtained by average of 5-10 individual trees, and 60 family lines (36 clones) were used for these experiments.
The H/D ratio of superior clone was smaller than that of inferior clone.

5. Classification of candidate plus tree into different drought tolerance levels (fig.6 and table 1)

Stem volume rankings in two seed orchards were used for this analysis. The stem volume ranking in Kibwezi seed orchard were deducted from that of Tiva seed orchard (fig.6), and deducted values were divided it into five categories (Table. 1). The growth index shown in table 1 was calculated by dividing the stem volume measured at 7 years after planting in Tiva orchard into five categories.

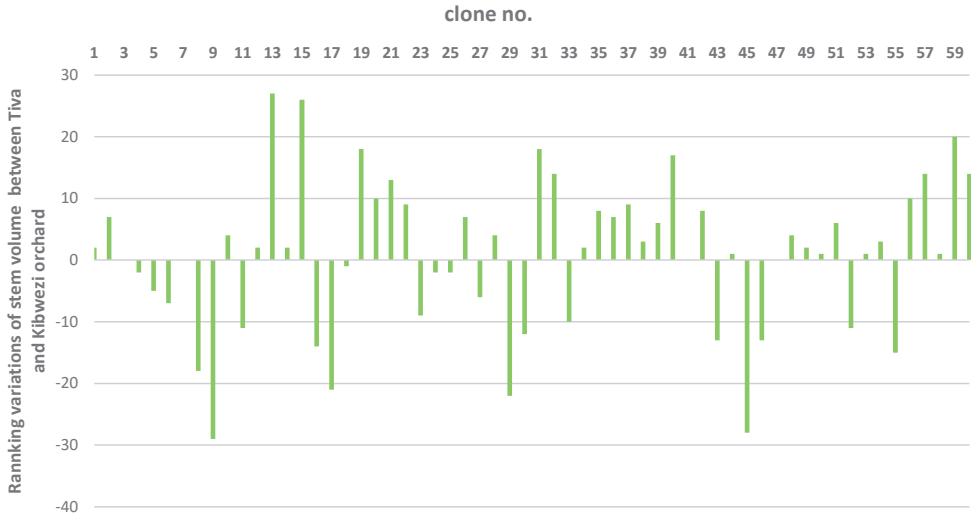


Figure 5 Ranking variation of stem volume in Tiva and Kibwezi orchards.
The averaged stem volume of each clone obtained from Tiva and Kibwezi seed orchards was used for evaluating the drought tolerance.
The drought index was calculated by dividing the ranking variation into five categories.

Table 1 Growth and drought Indices of selected plus trees.

Clone no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Growth index	1	2	2	2	3	5	3	5	3	1	5	1	2	4	1	4	2	5	1	4
Drought index	3	4	—	2	2	2	—	1	1	4	2	3	5	3	5	1	1	2	5	5

Clone no.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Growth index	1	4	4	2	2	2	5	4	5	3	1	3	4	4	1	1	3	4	1	3
Drought index	5	4	2	2	2	4	2	4	1	1	5	5	2	3	4	4	4	3	4	5

Clone no.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Growth index	1	3	3	5	5	3	5	5	5	4	5	4	3	2	2	1	2	4	3	2
Drought index	3	4	1	3	1	1	2	4	3	3	4	2	3	3	1	5	5	3	5	5

:recommended clone
The growth index was calculated by dividing the stem volume of each clone measured at 7 years after planting in Tiva orchard into five categories.
The drought index was calculated by dividing the ranking variation (fig.5) into five categories.
The recommended clone was selected as a clone which has indices more than 3 in both items.