Tree Breeding to Support Commercial Plantation Forestry Investments in the Drylands of Kenya

A case of *Melia volkensii* and *Acacia tortilis*

Kenya Commercial Forestry Investment Conference & Expo
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Presenter: Jason G. Kariuki

Team

KEFRI

- **Jason Kariuki – PI Tree Breeder**
- **Dr James Ndufa, (Dr Muturi)– Project Manager**
- **Dr Stephen Omondi – DNA and Molecular work**
- **David Muchiri – Physiology and Drought tolerance**
- **Bernard Kamondo – Seed**
- **Patrick Mwenje – Scientist**
- **Valentor Okul – Scientist/ Breeder**
- **S. Auka – Forester - Assessments**
- **D. Mwende - Assessments**
- **Bernard Wambua – Assessments**
- **Mary Mwangi Forester**
- **Pius Matieka – Forester**
- **E. Kyalo - Nursery**

FTBC

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Mr Kobayashi

Dr S Hanaoka

Prof Gyokusen

Distribution of drylands in selected African Countries (Km^2)

Country	Humid	Moist Sub-Humid	Dry Sub-Humid	Semi Arid	Arid	Hyper-Arid	Total	Drylands	% Drylands
Rwanda	**5918**	**14244**	**5156**	**0**	**0**	**0**	**25,318**	**5156**	**20.4**
Uganda	**9597**	**171065**	**41876**	**19740**	**81**	**0**	**242359**	**61697**	**25.5**
Zambia	**6572**	**384156**	**241383**	**122022**	**0**	**0**	**754133**	**363405**	**48.2**
Mozambique	29649	349510	213831	195670	0	0	788660	409501	51.9
Malawi	3532	51600	60355	3020	0	0	118507	63375	53.5
Lesotho	1747	12269	14231	2243	0	0	30490	16474	54.0
Tanzania	20250	349026	350994	225534	0	0	945804	576528	61.0
Ethiopia	102973	218694	159276	342378	30291	432	854044	532377	62.3
Swaziland	0	3759	8594	4967	0	0	17320	13561	78.3
Kenya	**13,090**	**64,428**	**48,219**	**239,472**	**219,553**	**0**	**584,762**	**507,244**	**83.7**
South Africa	194	78477	150672	571952	406998	13383	1221676	1143005	93.6
Sudan	347	142692	161197	782155	631069	795550	2513010	2369971	94.3
Zimbabwe	1078	7985	55843	324919	2017	0	391842	382779	97.7
Botswana	0	0	0	0	494,624	84,939	579,563	579,563	100.0
Burundi	0	0	13711	58508	188993	14535	275747	275747	100.0
Eritrea	0	0	0	0	41769	74117	115886	115886	100.0
Namibia	0	0	0	410696	336198	79422	826316	826316	100.0
Somalia	0	0	0	122820	418855	94750	636425	636425	100.0
Total	**194947**	**1847905**	**1525338**	**3426096**	**2770448**	**1157128**	**10921862**	**8879010**	**81.3**

> 80% of Kenya is ASAL & forest cover < 10%

Drylands distribution in Kenya

% ASAL	Counties	% Kenya ASALS
100%	Isiolo, Marsabit, Garissa, Mandera, Wajir, Turkana	62
85-100%	Kitui, Tana River, Taita-Taveta, Kajiado, Samburu	25
50-85%	Embu, Meru, Machakos, Laikipia, West Pokot, Kilifi, Kwale, Baringo	10
30-50%	Lamu, Narok, Elgeyo Marakwet	3
Total		**83**

Arid zones classification

ARIDITY ZONE	ARIDITY INDEX*	GROWING SEASON (DAYS)	TYPICAL CROPS	FORESTRY POTENTIAL
HYPER –ARID	<0.05	0	No crop, no pasture	Nil
ARID	0.05 – 0.20	1 -59	No crops, marginal pasture	Marginal
SEMI-ARID	0.20 – 0.50	60 - 119	Bulrush millet, sorghum, sesame	Low - medium
DRY SUB-HUMID	0.50 – 0.65	120 - 179	Maize, bean, groundnut, peas, barley, wheat	Medium - high
MOIST SUB-HUMID	0.65 – 1.0	180 - 269	Maize, cotton, sweet potato, finger millet	High
HUMID	>1.0	> 270	Cassava, coffee, banana, tea, sugar cane	High

Aridity index refers to rainfall/ evapotranspiration ratio

Where agricultural potential is high, forestry is outcompeted by food production

Large-scale tree planning in ASALs can be achieved through prudent choice of species that are not only drought tolerant, but also productive to meet the needs of the local communities.

Species 1: Melia volkensii

- Endemic to Eastern Africa
- A drought tolerant, termite resistant
- Produces high quality timber (used for high value furniture, doors and windows frames)
- Provides fodder and fruits for animals
- Potential for large scale dryland forestry development

Suitable conditions for growing M*elia volkensii*

Arid and semi-arid areas

- Rainfall: 250-1000 mm
- Altitude: sea level - 1700 m above sea level
- Soils: Grows well on most sandy soils but prefers sandy/loamy or sandy clay soils with <u>good drainage</u>

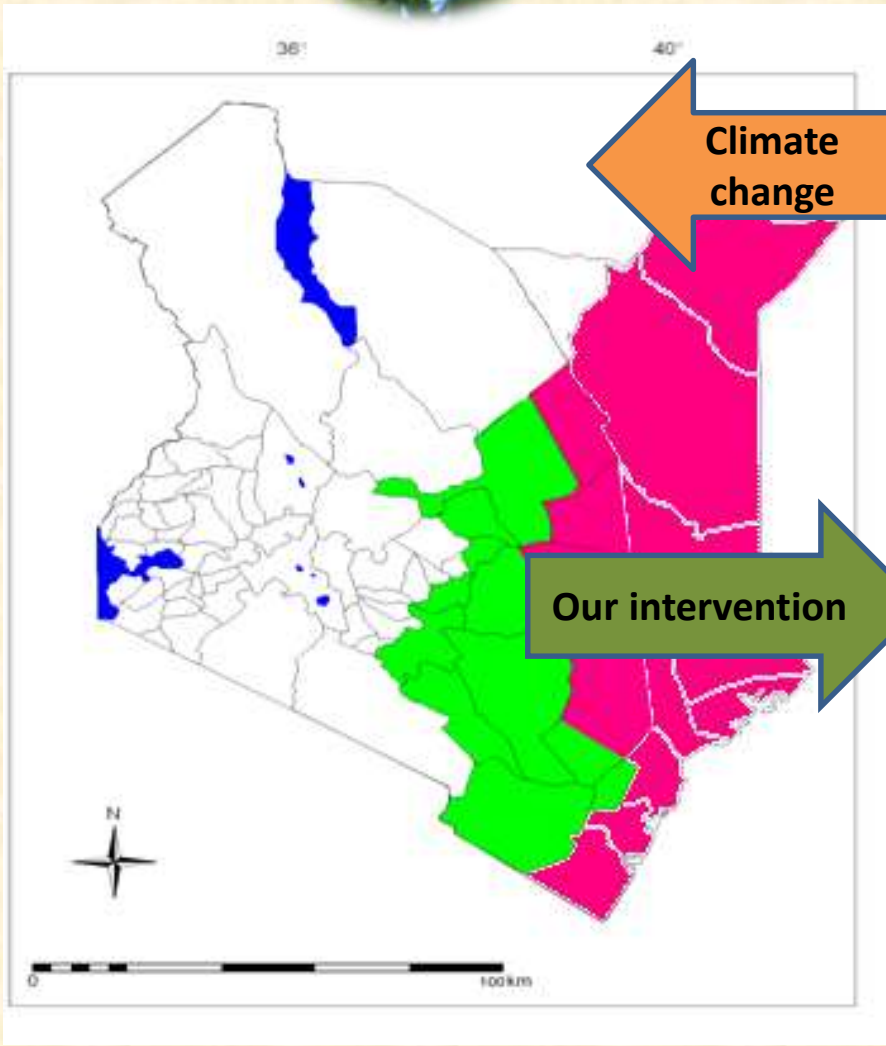
Species 2: Acacia tortilis

- Fast growing, drought tolerant
- Provides fodder
- Fuelwood and charcoal
- Fuelwood of high calorific value (4,400 kcal/kg)
- Good coppicing ability

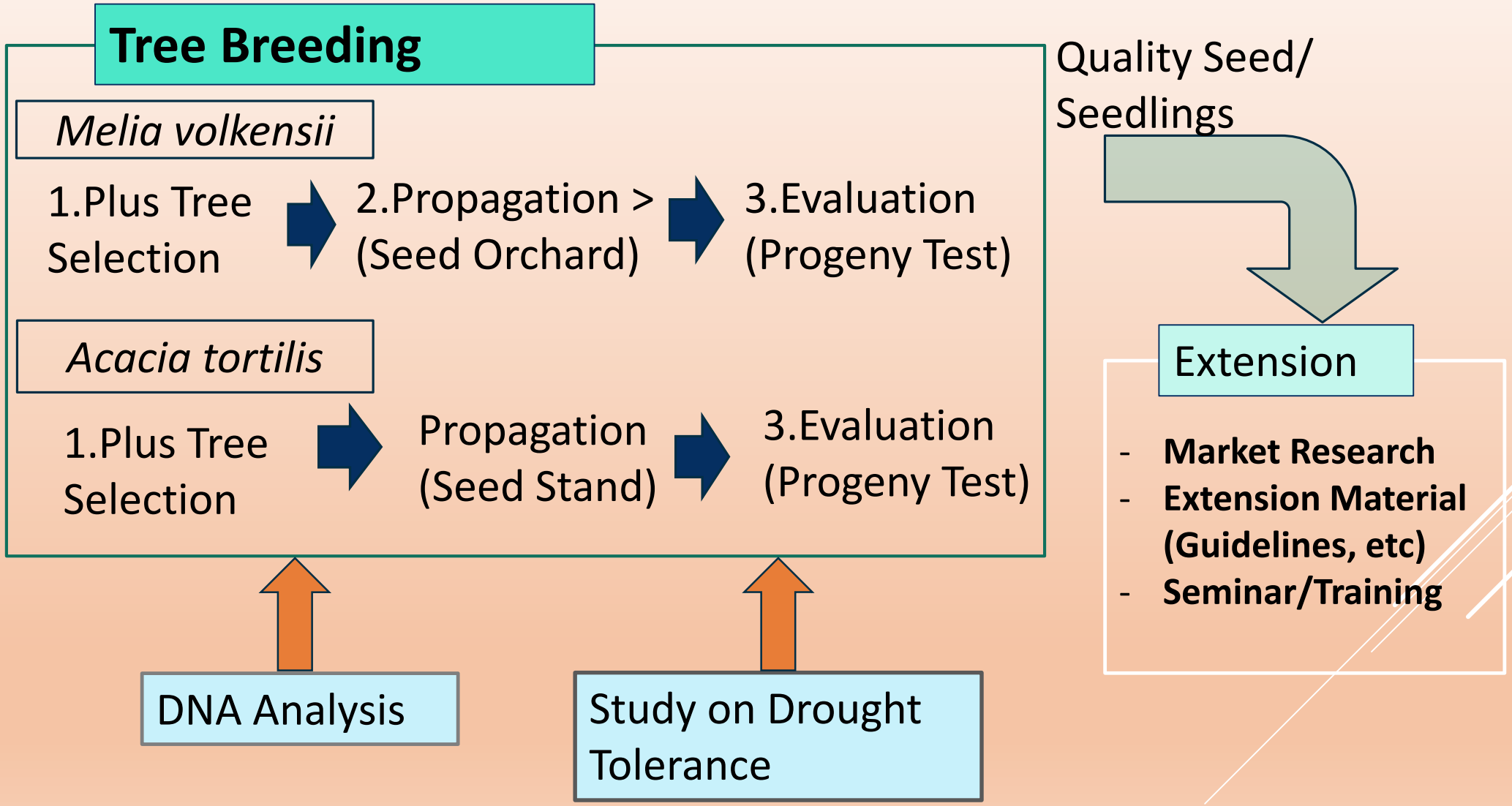
Breeding Objectives Melia and *Acacia tortilis*

The main objective of tree breeding is to supply genetically superior materials that are adapted to target planting areas, solve specific problems and produce desired products:

- **Increase *adaptability* (survival and growth on more arid sites)**
- **Increased productivity (increased volume production)**
- **Improve quality (improved wood properties for end use)**



Tree breeding process



Melia volkensii tree breeding cycle

Grafting

Selection

Orchard

Testing at PTS

Seed production

Commercial forests

Genetic improvement from 1st to next generations

wild

1st generation

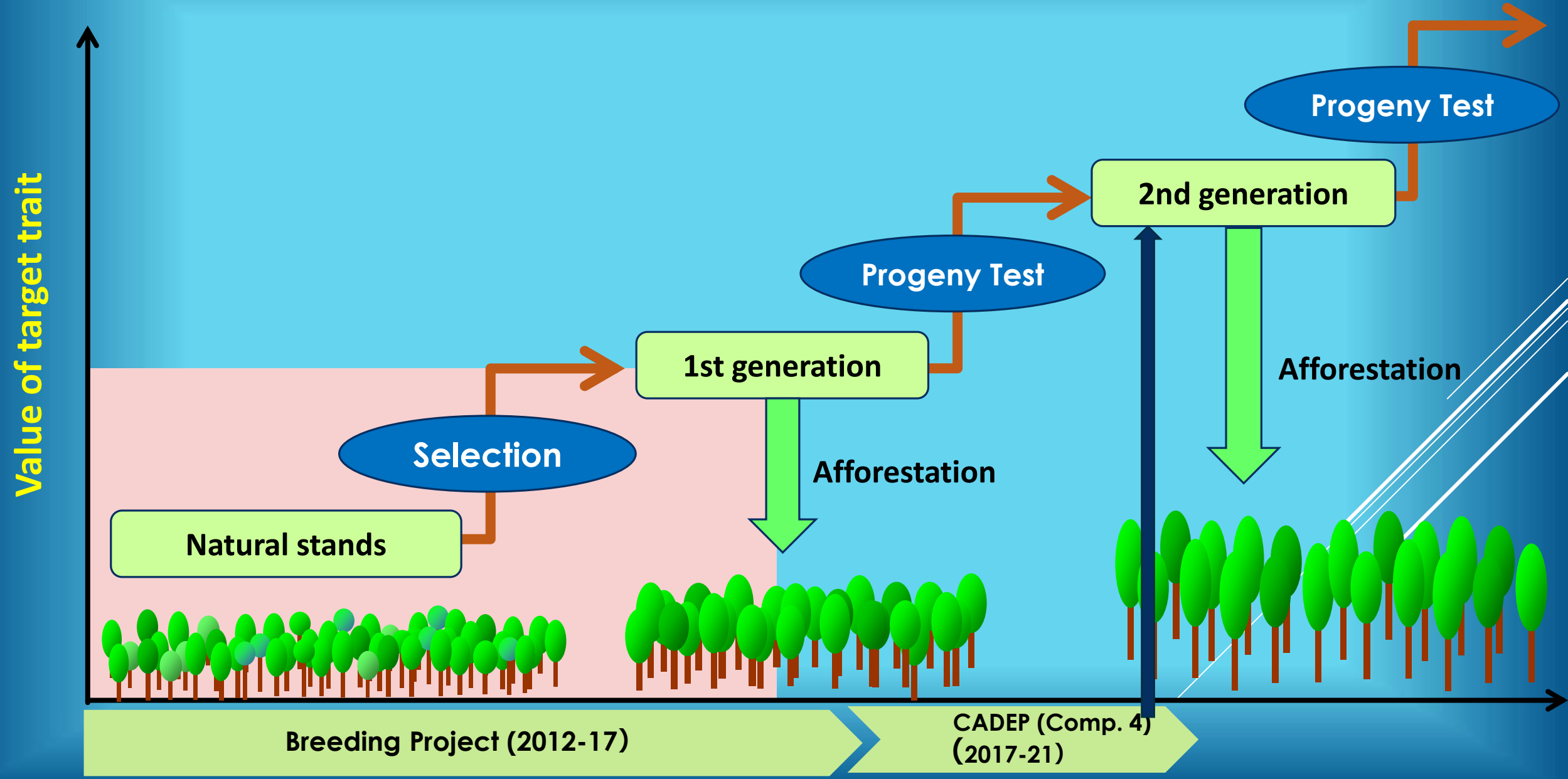
2nd generation

3rd generation

CO^2 CO^2 CO^2

$

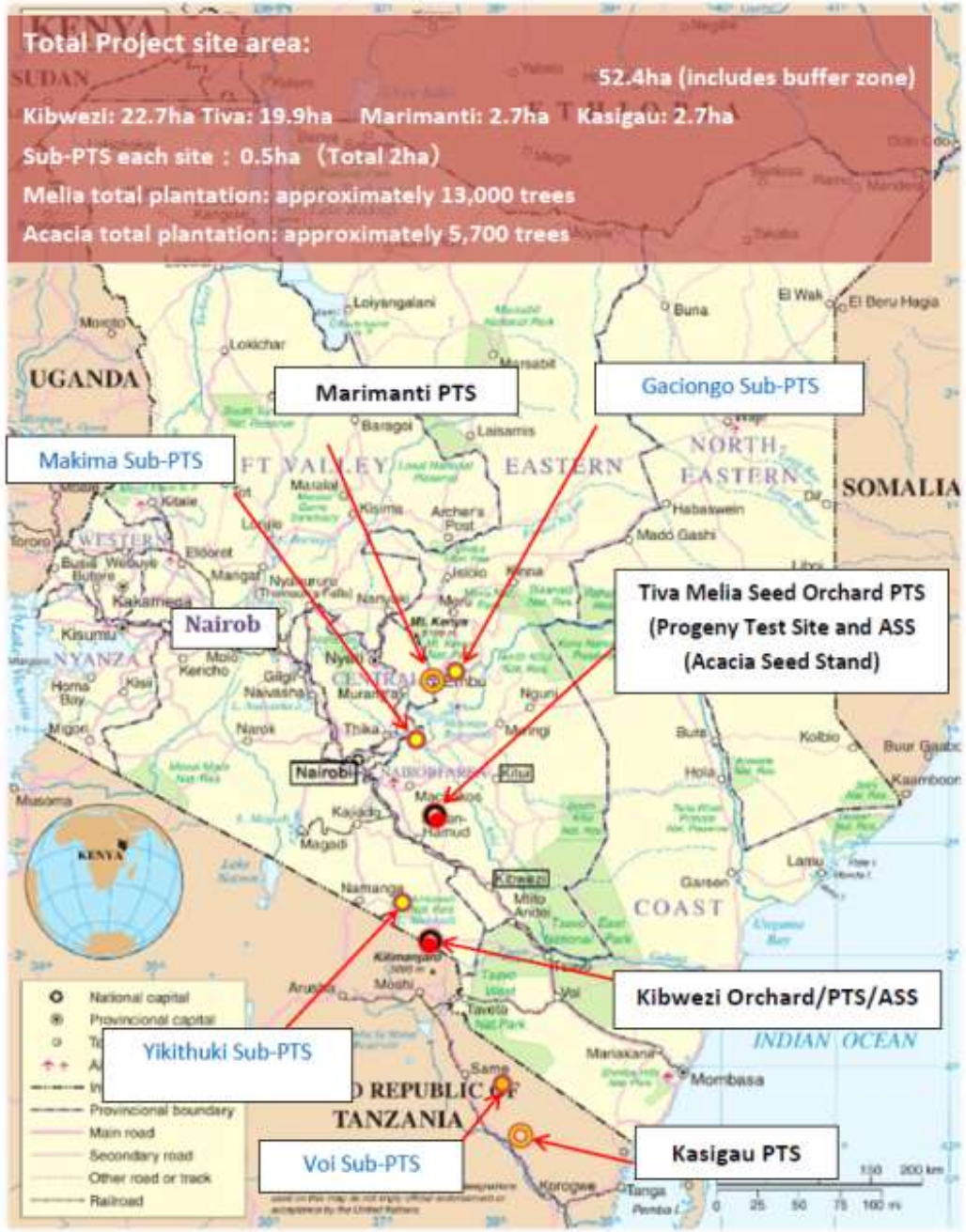
Roadmap for Tree Breeding



Project Sites: Melia and Acacia

6: LOCATION OF THE PROJECT SITES

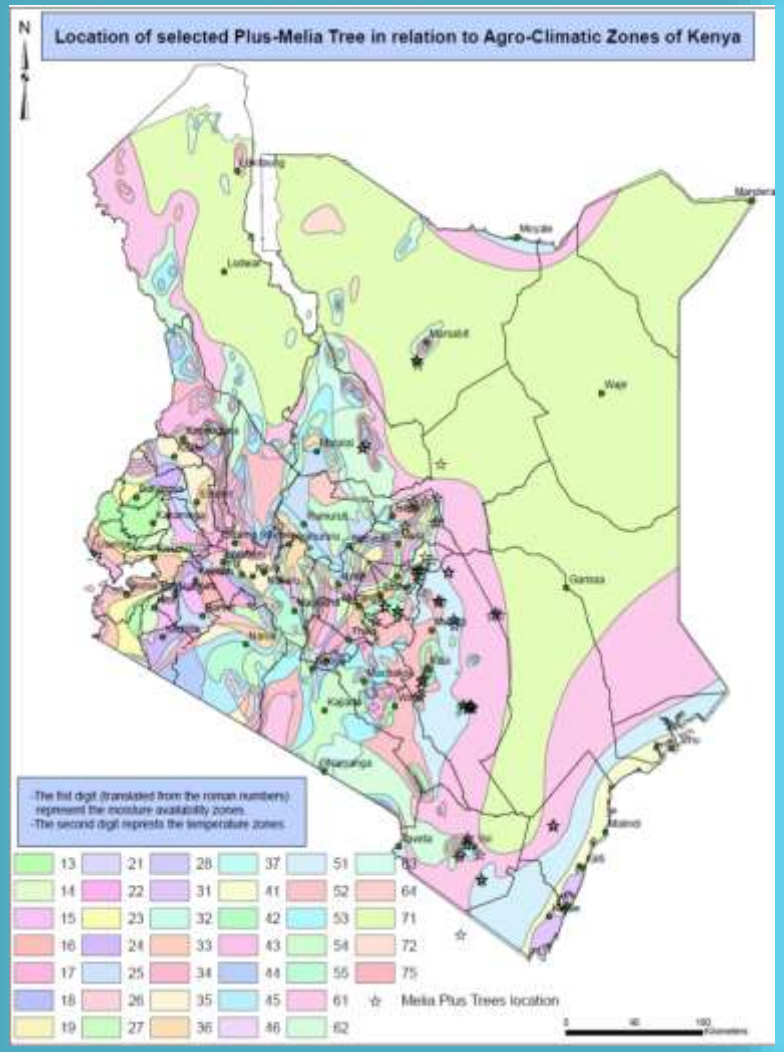
Melia Orchards/Progeny Test Sites & Acacia Seed Stands Location Map



MELIA BREEDING PROCESS

- ✓Selection of Candidate Plus Trees (CPTs) - Melia/Acacia
- ✓Establishment of Seed Orchards
- ✓ Progeny tests and evaluation of CPTs
- ✓Production of improved seed
- ✓Removal of inferior families for <u>improvement</u> of overall quality of seed orchard seed
- ✓Selection for 2nd generation and establishment of 2nd generation seed orchards

A. Candidate Plus Tree Selection



Distribution of plus trees of *M. volkensii* in various region of Kenya

Region	TRANSECT	Number of Plus tree	Total
Northen	Wamba-Marsabit	10	24
	Garba-Wamba	6	
	Meru-Isiolo	4	
	Garissa-Bangale	4	
Eastern	Embu-Ishiara-Gatunga	11	32
	Mwingi - Tseikuru	8	
	Embu-Dams	9	
	Mwingi - Nuu	4	
Central	Mwea - Specian	2	2
Central Eastern	Katulani-Kavisuni	10	10
South Eastern	Mutha - Inyali	12	12
Coastal	Voi-Galana	10	20
	Voi-Mwatate	10	

Selected 100 Candidate Plus Trees (CPTs) in various regions

Plus Trees – A tree appearing distinctly superior in characteristics of interest compared to others on same site

Some selected *Melia volkensii* Candidate Plus Trees


Tharaka


Mwea


Marimanti


Voi


Voi-Galana


Scions


Grafting


grafts

Scion collection


Ready to plant

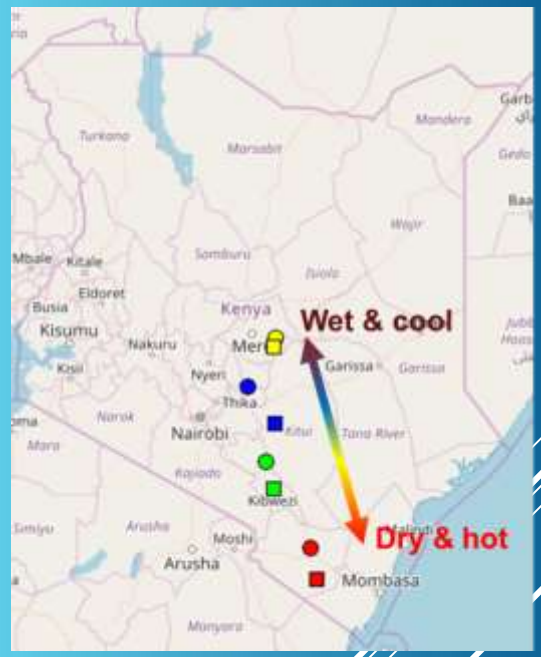
B. Seed orchard establishment

- 6000 grafts from selected plus trees were produced and used to establish two 11-hectare clonal in Kitui and Kibwezi
- Each orchard contains 3000 trees and an area of 11 Ha

100 CPTs (1st gen.)
30 stems/CPT
3,000 stems/orchard

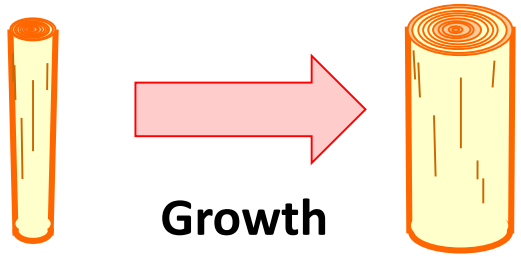
C: Progeny testing

- Seed produced from tree improvement breeding efforts are used to establish progeny tests to:
  - 1) provide genetic information about the selected parent trees
  - 2) Assess adaptability for difference areas
  - 3) provide an improved population of trees from which the next generation of select trees is made
- The results are used to assess the genetic worth of the original selections, to make selections for the next generation
- 8 progeny trials established in 2014/15 (860 treesx4 sites; 160 trees x 4 sites
- Assessments done every 6 months to 4 years, annually thereafter

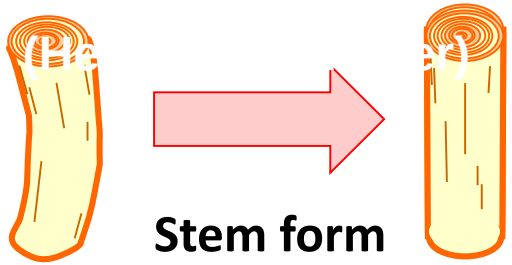


Key (Top to bottom)
Gaciongo Sub-PTS
Marimanti Main PTS
Makima Sub-PTS
Tiva Main-PTS
Ikithuki Sub-PTS
Kibwezi Main PTS
Voi Sub-PTS
Kasigau Main PTS

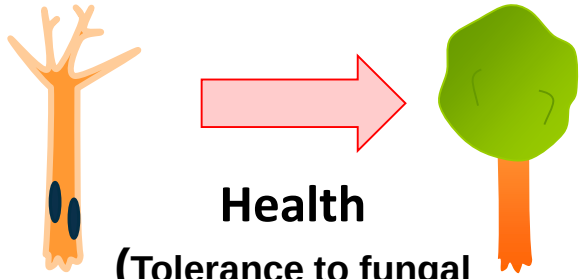
Tree traits assessed in progeny tests



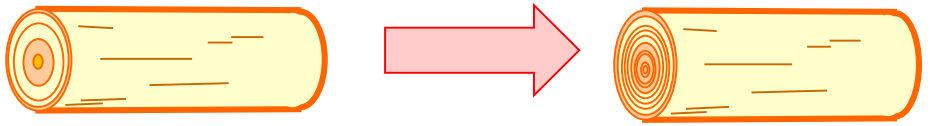
Growth
(Height & Diameter)



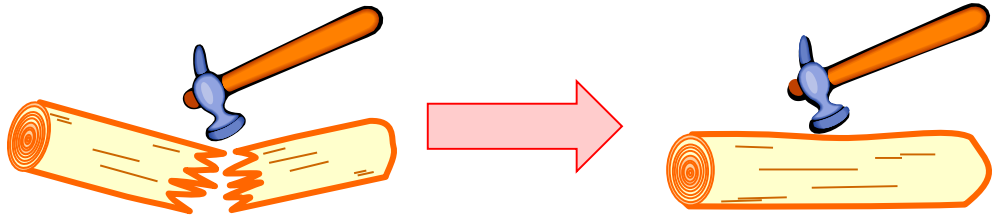
Stem form



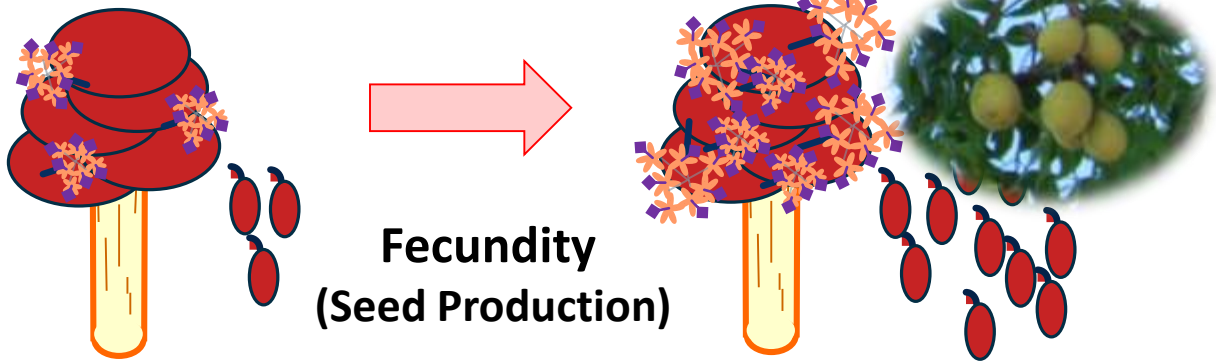
Health
(Tolerance to fungal disease



High density



Strength



Fecundity
(Seed Production)

Melia volkensii progeny trials

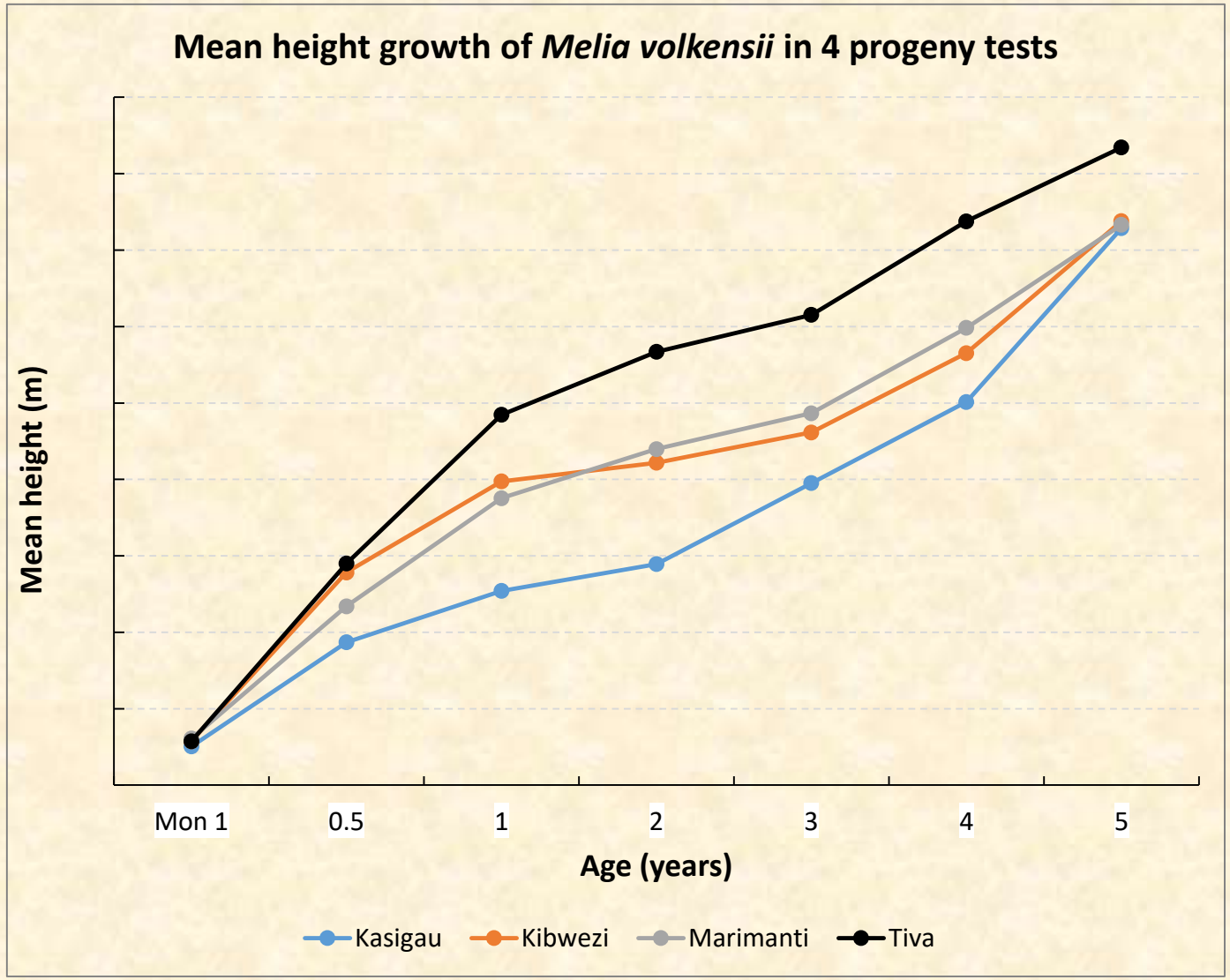
Voi

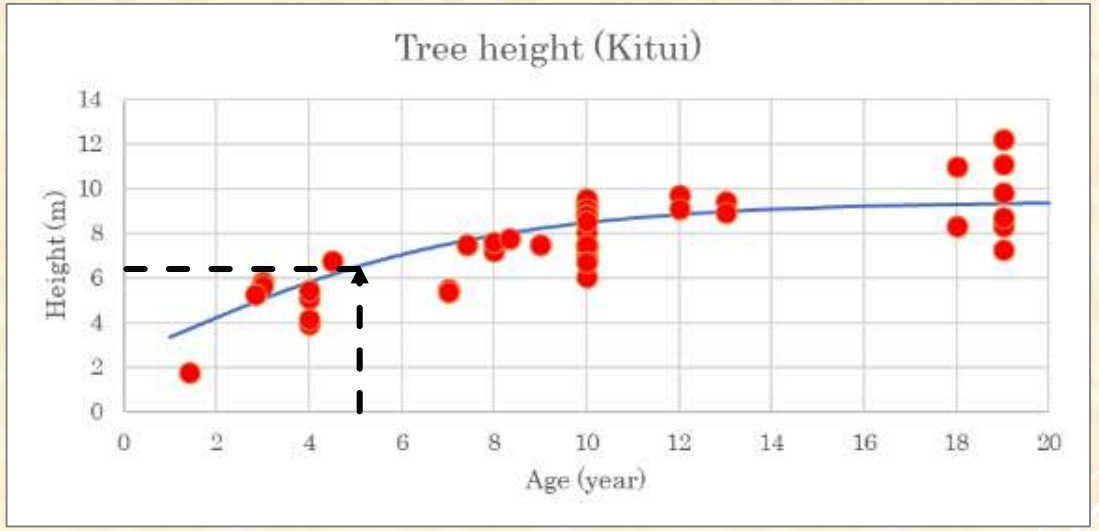
Marimanti 2018

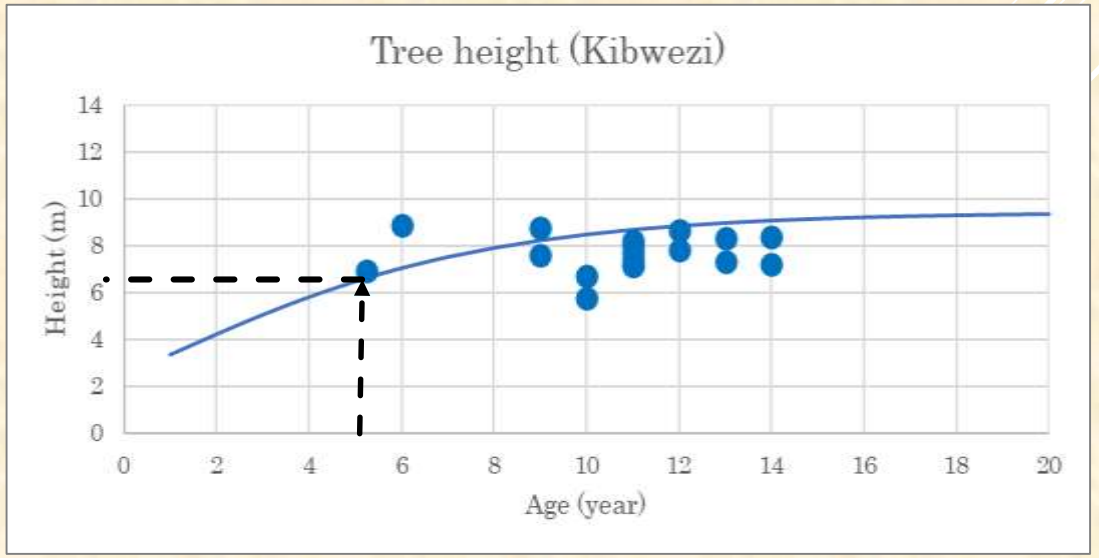
Tiva 2019

4 YEAR OLD IMPROVED MELIA FROM VARIOUS PROGENY TEST SITES

Melia height growth at 5 years

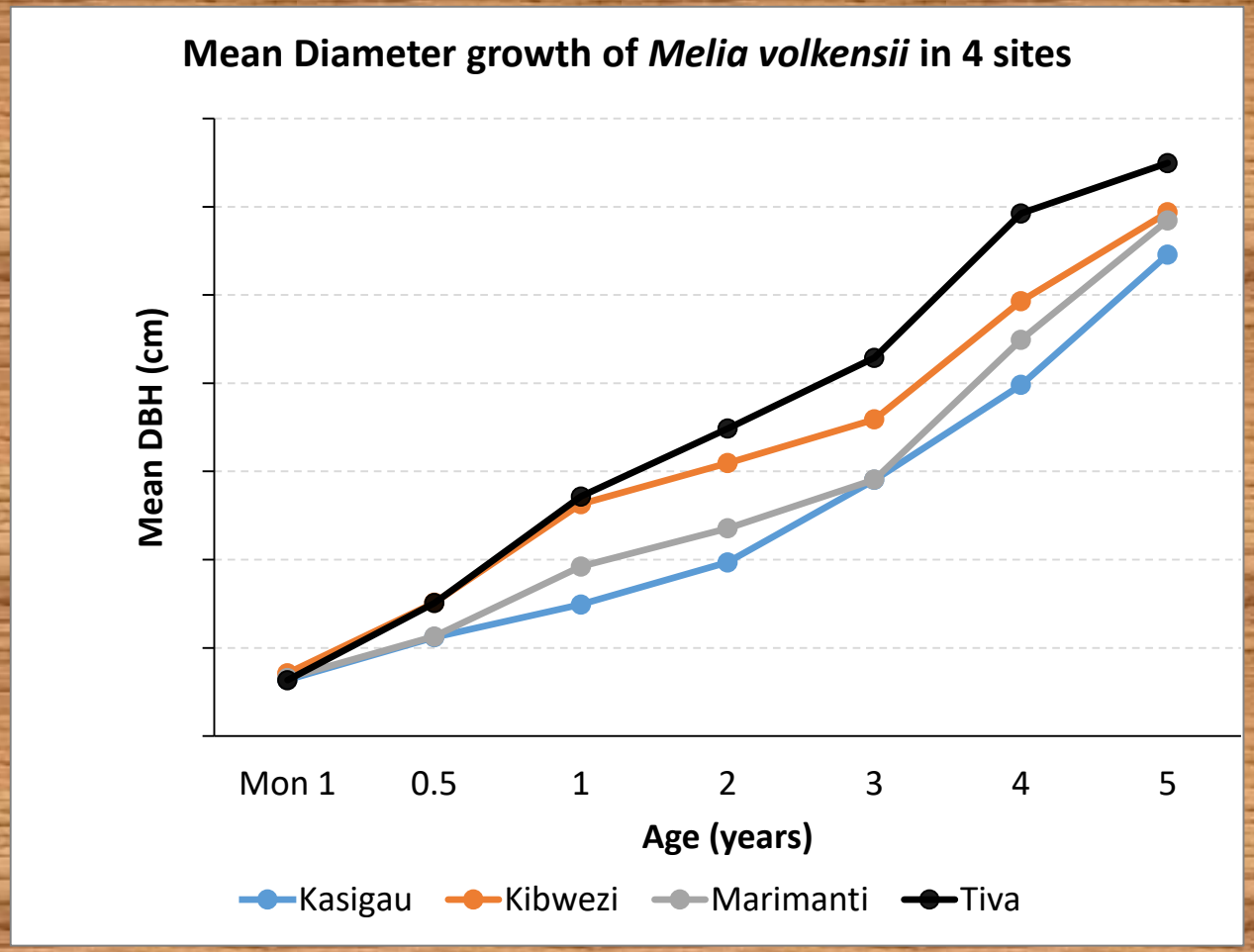






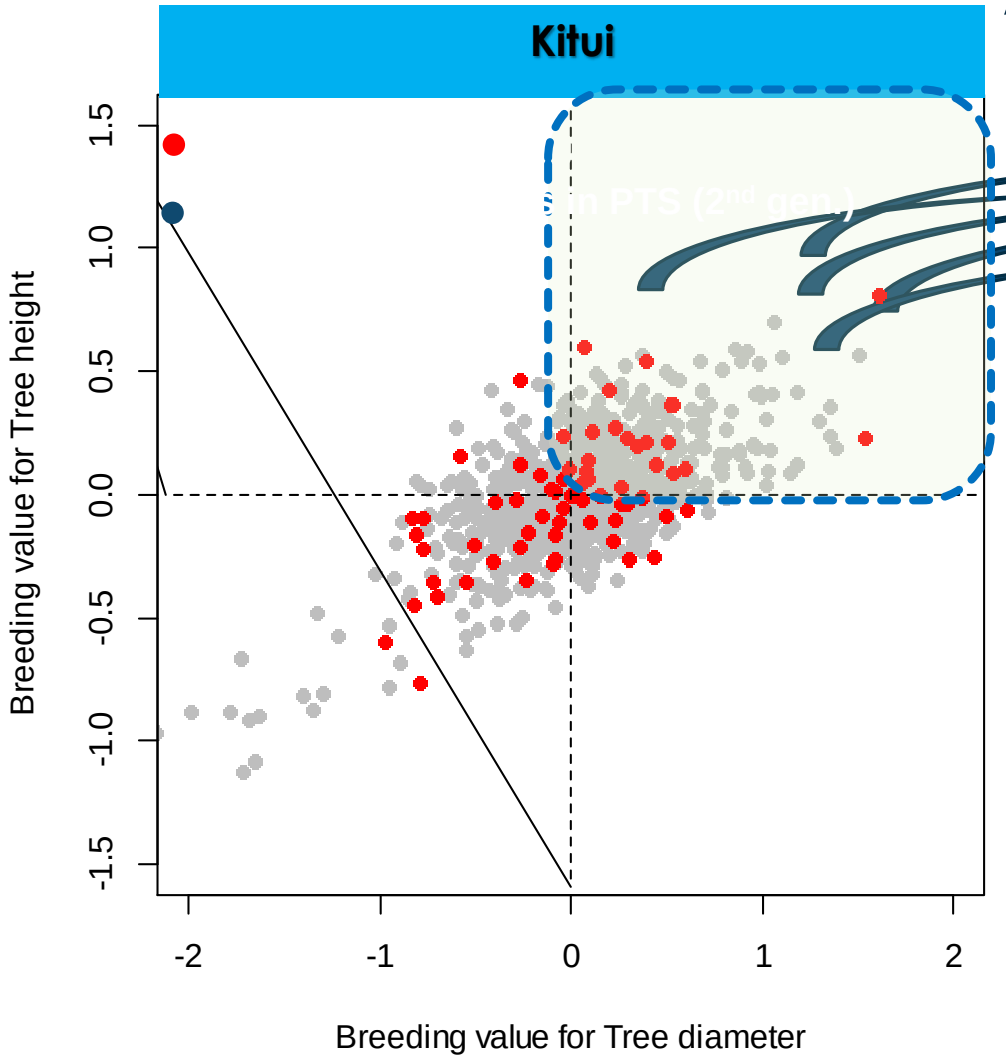
Dr Gyokusen, 2021

Melia volkensii diameter and volume growth at 5 years



Second Generation selection

After getting the robust estimation of genetic performance through breeding analysis, top 10% progenies were selected to constitute 2nd gen. *Melia*.



About 860 progenies (●)

60~70 mothers (●)

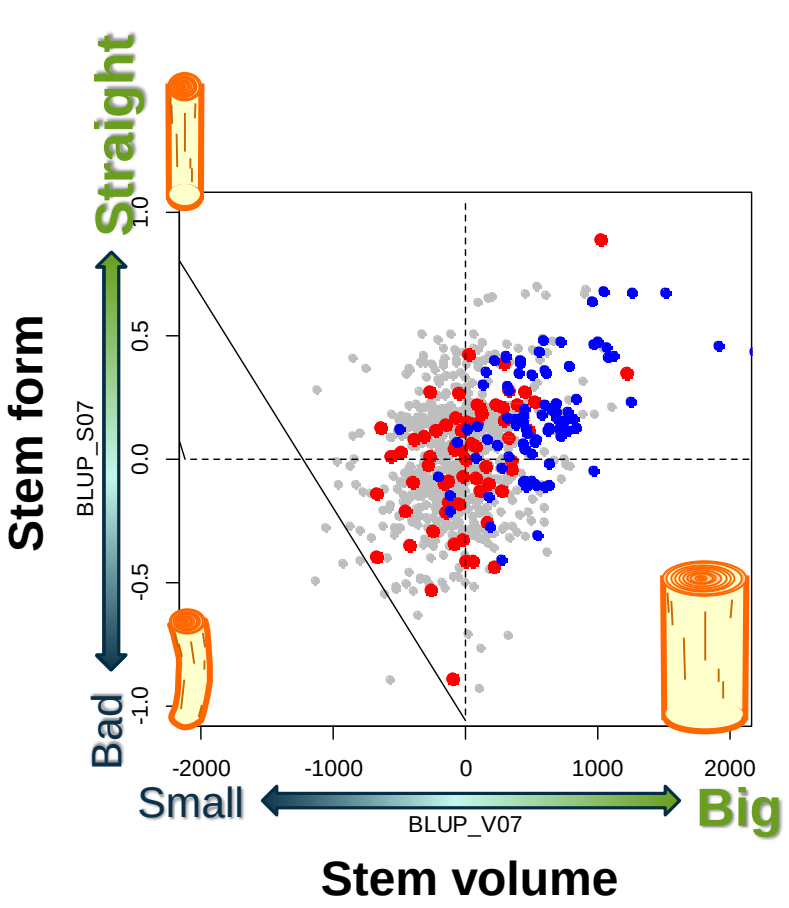
10% Superiors

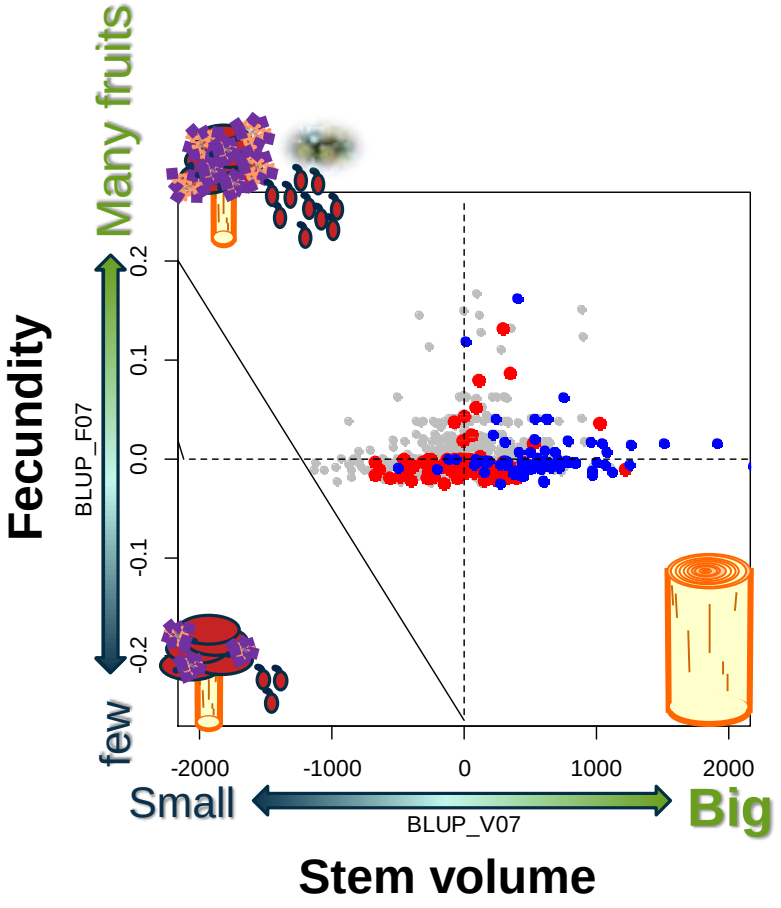
After our statistical analysis,
about 10% (●, about 86 trees per site)
out of the all progenies initially planted in PTS
Were selected as the 2nd generation *Melia*.

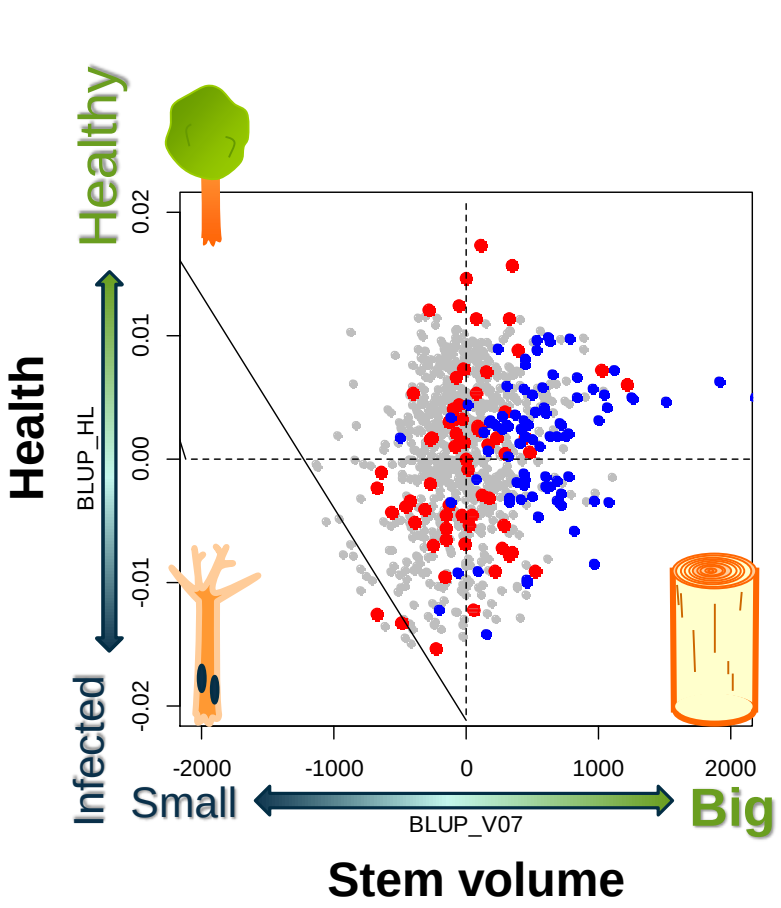
To maintain genetic diversity,
¾ of 1st gen. *Melia* (about 50 out of 60~70 mothers)
contributed to the selected 2nd gen. progenies (●).

Multiple traits (Volume, Stem form, Fecundity and Health) were used

~ Selections from Tiva PTS based on 4-years-old data~





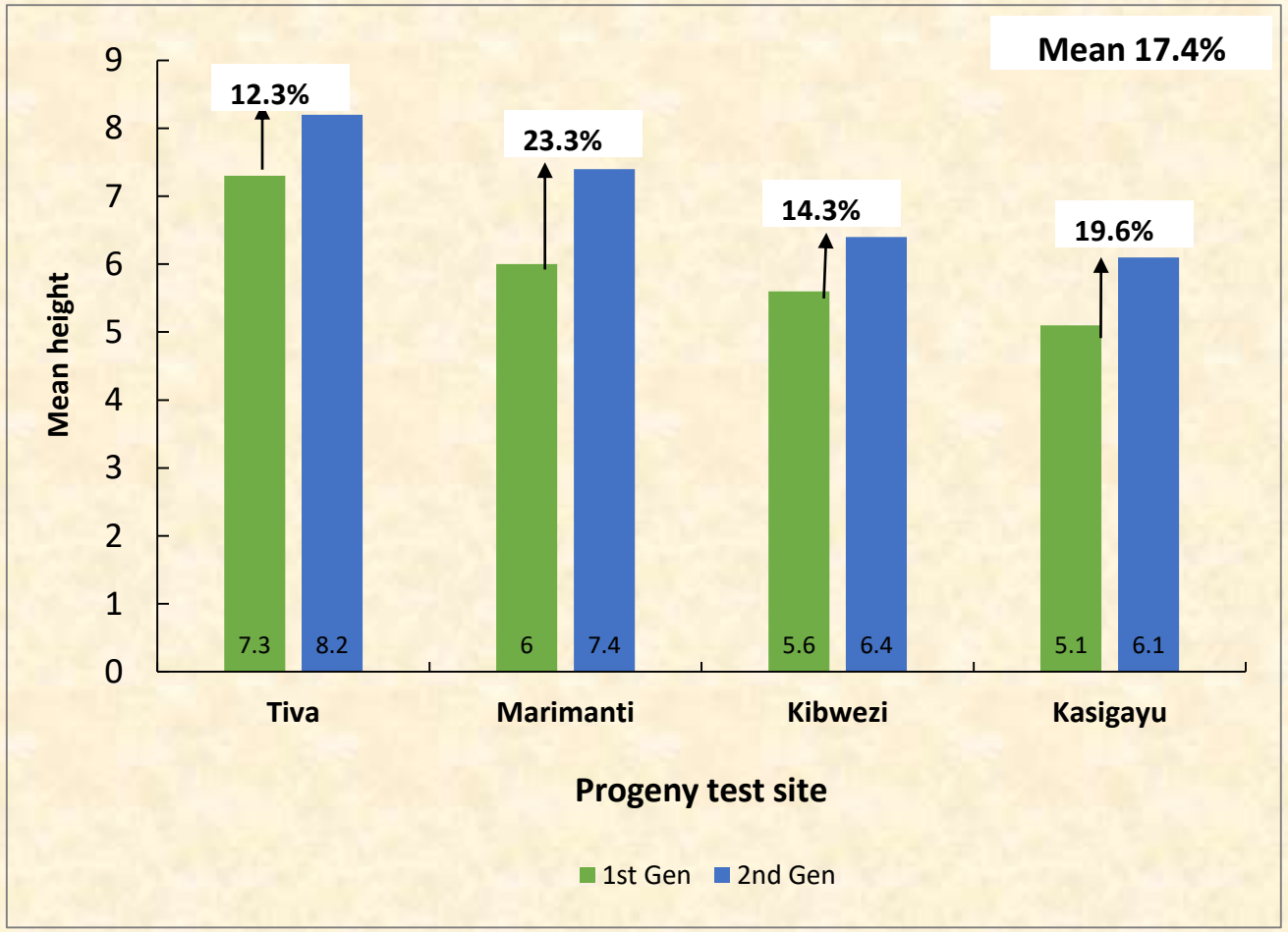


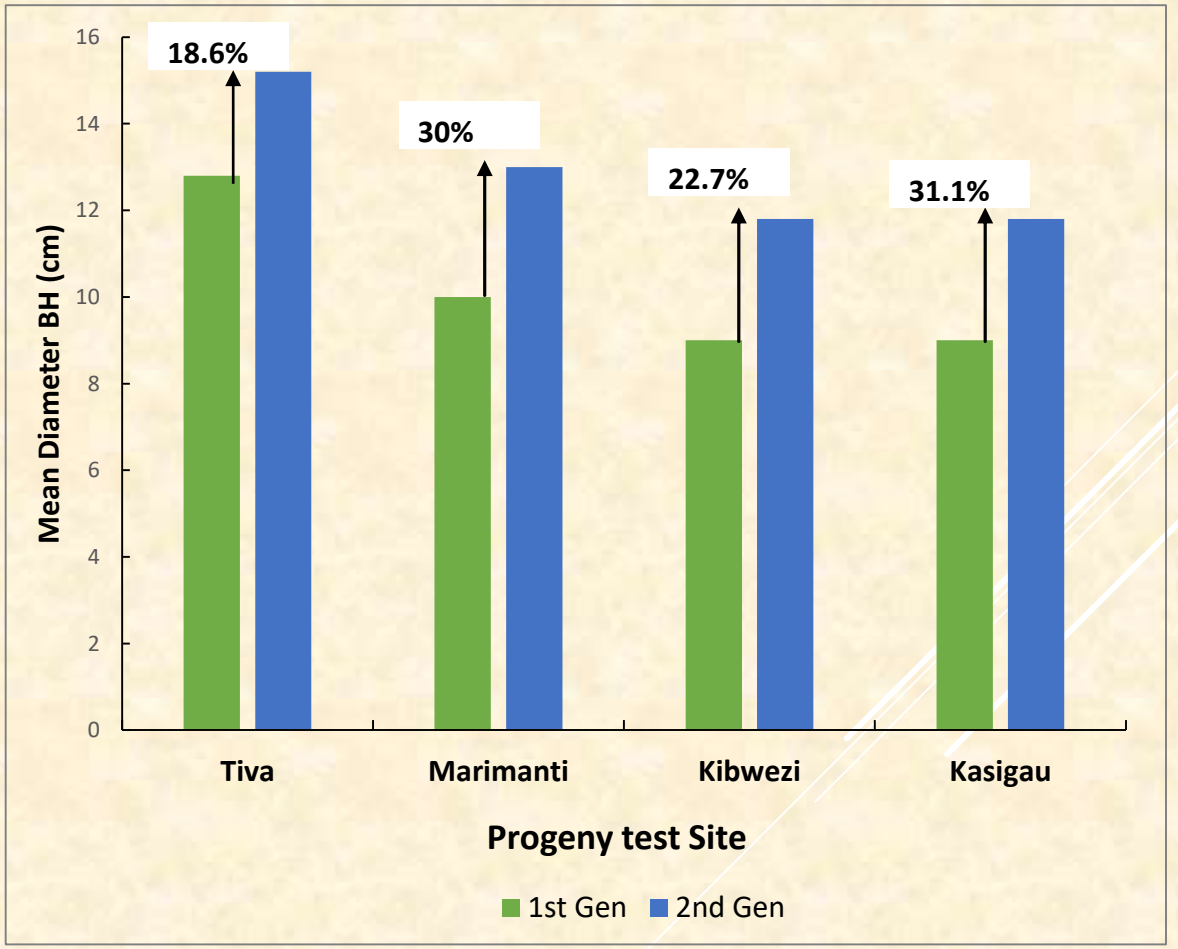
- Mothers (1st gen.)
- Selected Good Progenies in PTS (2nd gen. selected)
- All Progenies planted in PTS (2nd gen.)

Means at 4-yr- age: ALL vs selected 2nd Gen progenies

Tree height:	**7.3 m**	→ **8.2 m**
Diameter:	**12.8cm**	→ **15.2cm**
Stem form index:	**3.6**	→ **4.2**

Growth comparison between mean of 1st and 2nd generation Melia volkensii





SITE	TIVA	MARIMANTI	KIBWEZI	KASIGAU	Mean %
Stem form Index	16%	22.2%	15.3%	17.6%	17.7%

NFP Page 106-110

STRATEGY 8.5

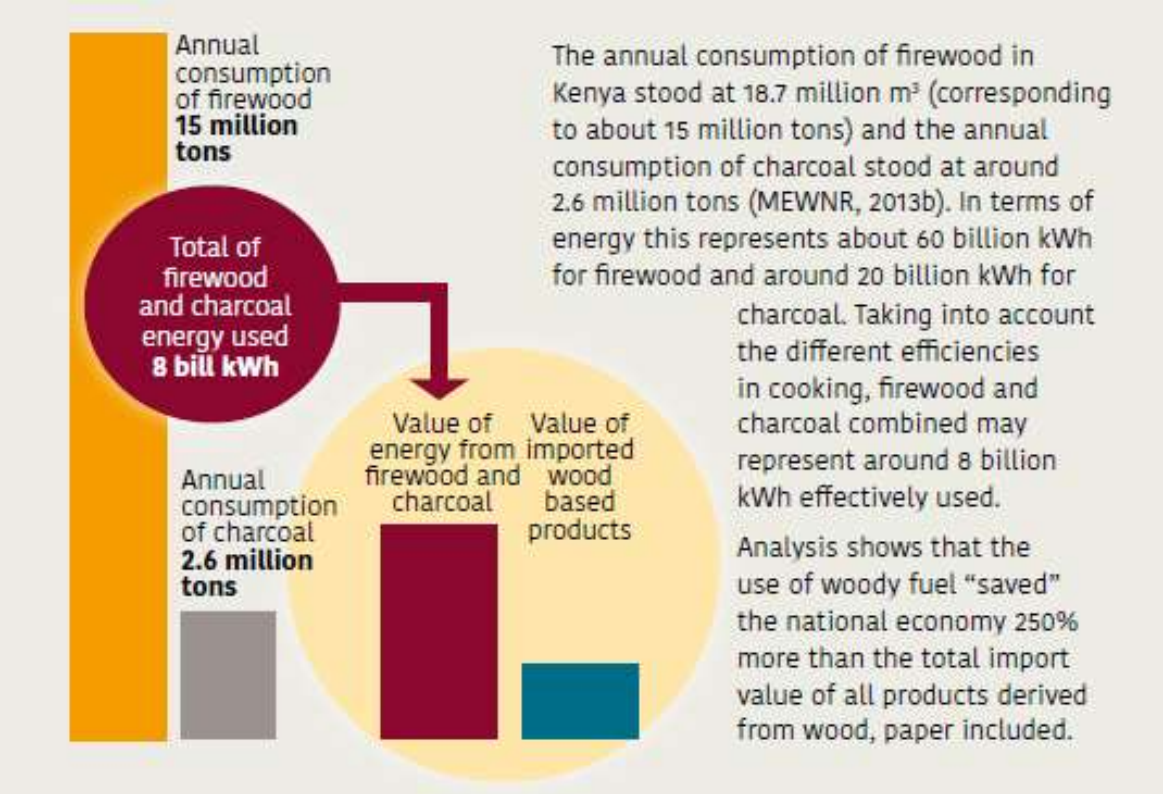
FOREST FOR ENERGY CLUSTER

Forest biomass is the main source of energy for most rural communities, food process ing industries and urban households in Kenya. Forest energy is critically important t the Kenyan economy in general and to the household economy in rural and urban areas

Firewood is used mainly for cooking and heating and is sourced locally. Other alterna tive sources such as electricity, liquid petroleum gas (LPG) and kerosene are costly an the supply is irregular. This makes firewood the only viable source of energy for loca communities. The overdependence and growing demand call for sustainable manage ment of forest resources and efficient use of firewood.

The NFP considers the sustainable development goal on right of access to energy as basic human right and proposes strategies for meeting the demand through commer d adopting

Programme strategies	Programme outcomes
.....	.....
Integrate forest energy production into county land use plans	• Reduced degradation of natural resources • Reduced dependence on public forests for energy
Promote commercial tree growing for biomass energy production	• Increased income for commercial tree growers
Develop charcoal value chain and standards	• Increased income and livelihoods • improved charcoal enterprises.



Some selected Candidate plus trees of *Acacia tortilis*

- 100 CPTs selected across the country
- Seed was collected from the CPTs and subsequently used for establishment of seed stands /progeny tests in 2015 and 2016

Acacia for April 2016 planting


Plus tree in Turbi area North
of Marsabit
30 04 2015

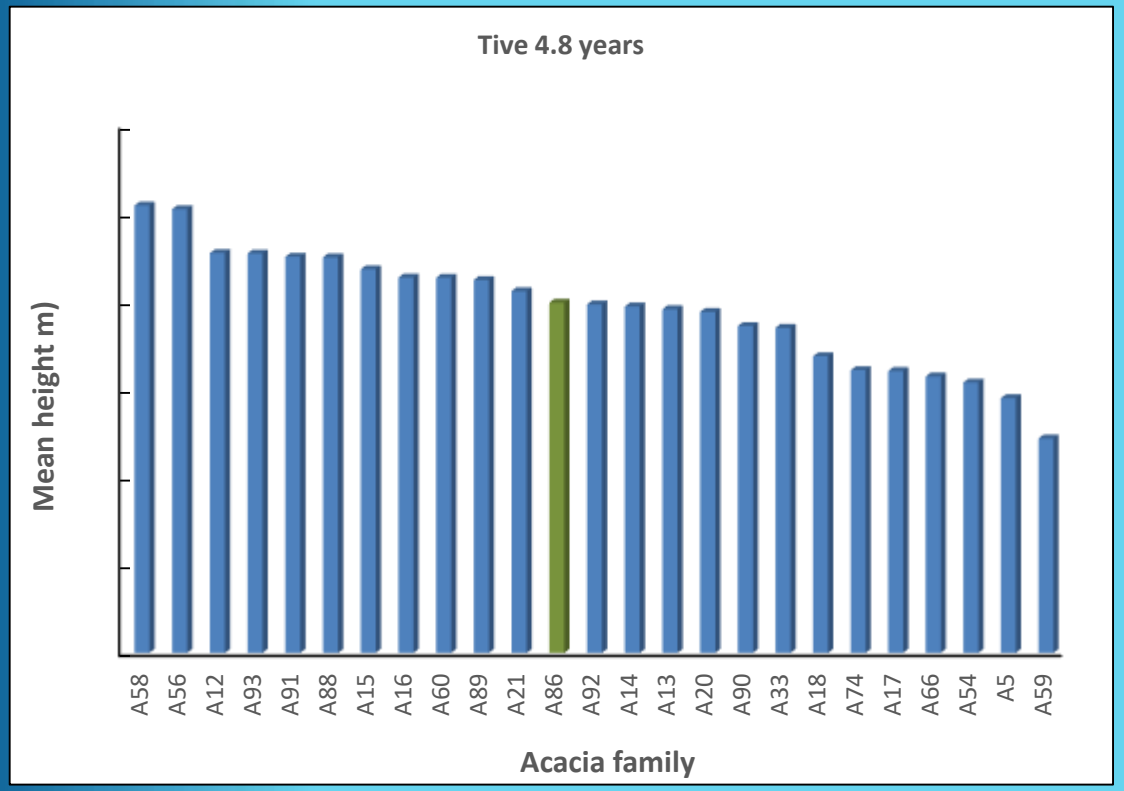

Labeled seedlings

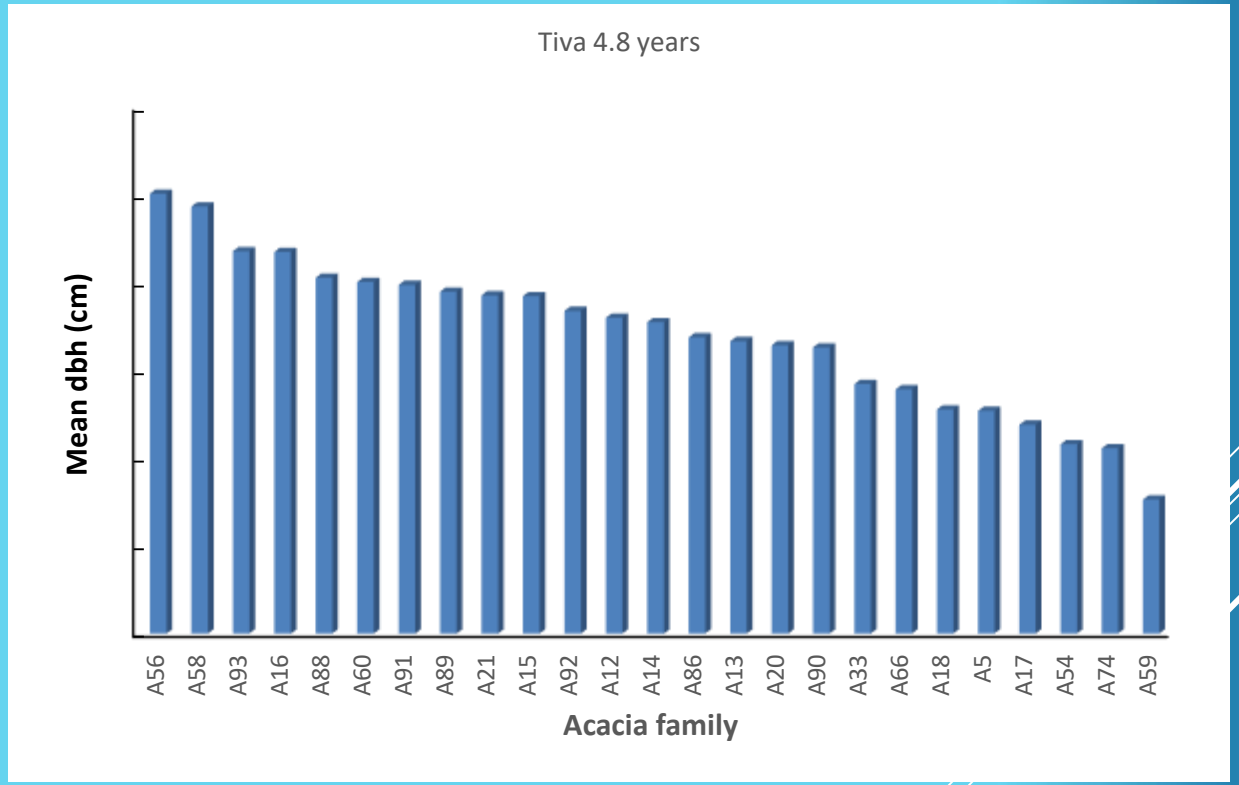

Seed stand/progeny test at 1 month Tiva


Seed stand/progeny test at 2.5 yrs, Tiva

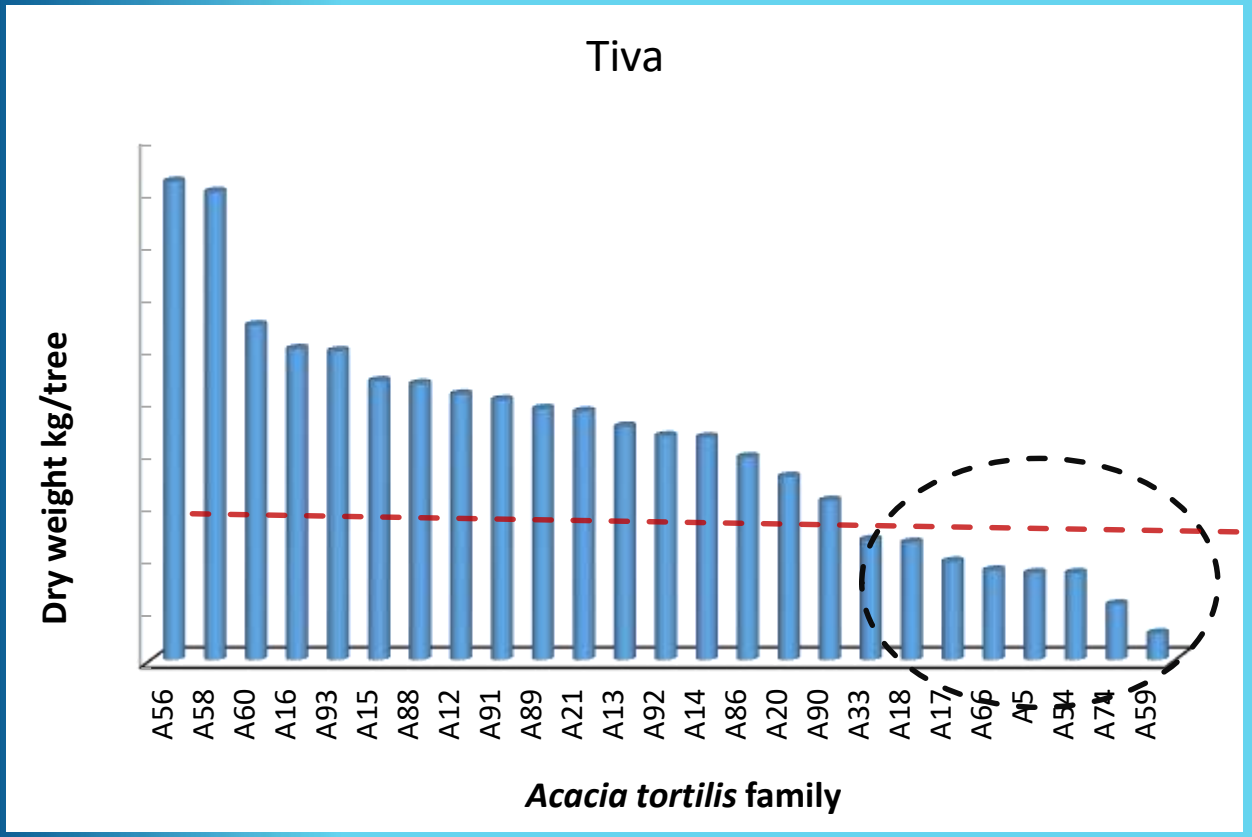
ACACIA PROGENY TEST (SEED STANDS)

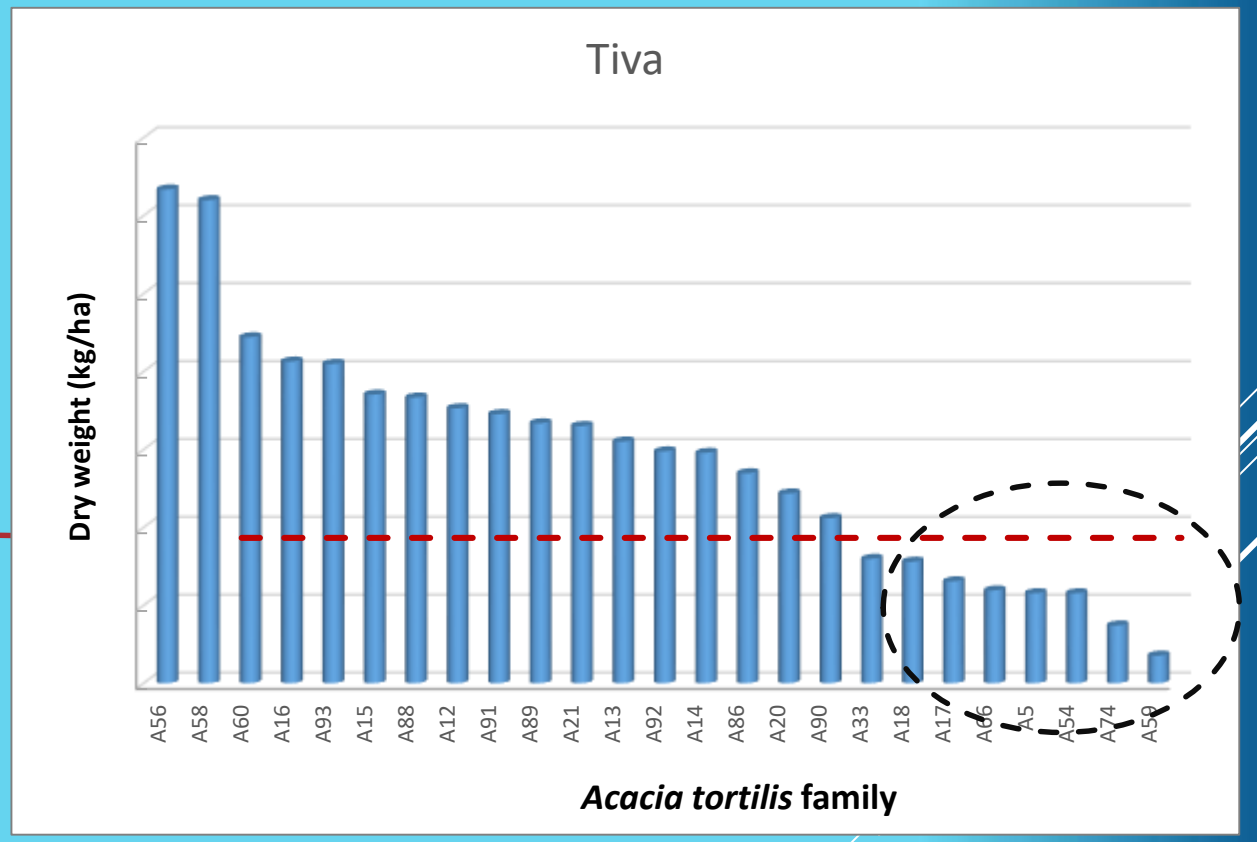
Growth of 1st generation *A. tortilis*





Biomass production in 1st generation *A. tortilis*





Felling - Kibwezi

Felling and clearing - Tiva

Cleared stand at Tiva

Cross cutting and disk sampling

Wood and root biomass collection

Weighing samples

Taking wood density using Pilodyn

Tree harvested stump and cut wood disks for laboratory density tests

Thinning and pylodin measurement (for density) of Acacia tortilis 2020/2021

Collaboration with stakeholders in distribution of superior varieties of *Melia volkensii*

Tree Breeding

JICA, KEFRI & FTBC

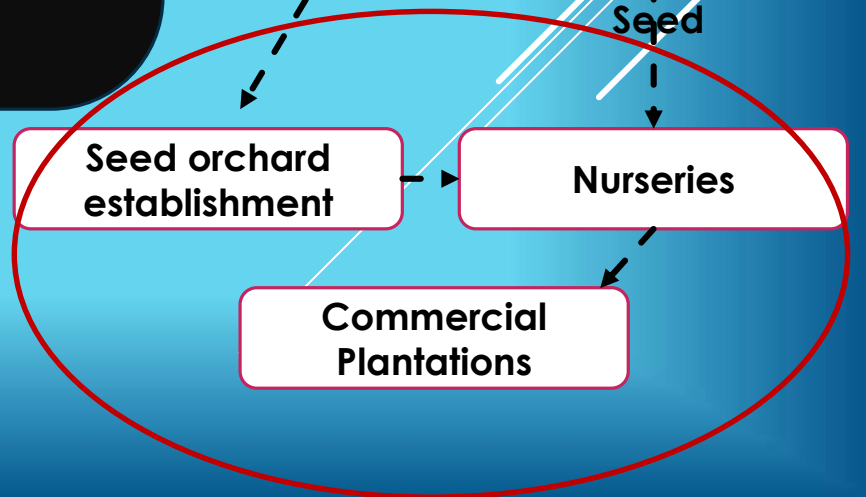
Materials (Improved seeds, seedlings, grafts etc.)
Techniques (management, breeding etc.)

Promotion of *Melia* growing in ASALs

KFS,
County Governments

Private sector, Individuals, and NGOs/CBOs

Capacity Development of County Governments/Private sector



Investment opportunities in drylands

1 Establish *Melia volkensii* seed orchards (2nd generation)

2. Establish nurseries

3. Commercial plantations of Melia for timber production

4. Commercial plantations of *Acacia tortilis* for biomass energy production

1. Establish 2nd generation production seed orchards

Partnership with KEFRI through MoU/MoA

- **Planting:** 30 families x 5 grafts each/6 blocks = 800 trees. Area needed at 7x7m spacing = 4 hectares
- **Production:** 600 trees x 3 kg = 2,100kg/yr x 7,000/- = 12,600,000/- per year. *Seed production from 3 years*
- ***Establishment costs:*** *Land ploughing, fencing, cost of grafting, Labour**
- *KEFRI : Clones, Orchard design, Technical Advice*

2. Establish improved Melia nursery

- **Target: 50,000 seedlings**
- **Area: 0.5 ha**
- **Seed purchase 15kg x7000 = 105,000**
- ***Establishment costs: Nursery preparation, fencing, Labour, nursery inputs****
- ***Sale 50,000 x 70/- = 3,500,000/-***
- ***Demand is very high***

MANUAL FOR ESTABLISHING AND MANAGING *MELIA VOLKENSII* SEED ORCHARDS IN KENYA

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GUIDELINE ON CLONAL PROPAGATION OF *MELIA VOLKENSII*




GUIDELINES FOR ESTABLISHMENT AND MANAGEMENT OF *ACACIA TORTILIS* SEED STANDS IN KENYA

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GENETIC PERFORMANCE AND PLUS TREE TRAITS TABLE FOR *MELIA VOLKENSII* IN THE DRYLANDS OF KENYA

TECHNICAL NOTE

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Guidelines on raising seedlings and growing of Improved *Melia volkensii*

For Seed/Seedling users



Melia at 2000 m a.s.l

Thank You