FORESTRY DEVELOPMENT TRUST

UENDELEZAJI MISITU TANZANIA

Fifteen-month height growth assessment and survival results for species and clonal hybrid trials in Southern Highlands

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ABSTRACT

Tanzania forestry industry like in other countries both regionally and internationally relies on utilization of exotic tree species which are fast growing and serves the demand for both solid wood and non-woody end products for decades. However, most of industrial plantations and woodlots owned by public, private and small-scale tree growers are derived from planting material which is limited in both the range of species and levels of genetic improvements respectively. With conflicting land uses options primarily spared for food production, there is a limited scope for expansion of land for plantation establishment mainly in prime productive areas due to population growth and climate changed induced planting of alternative crops mainly due to changes in climatic and edaphic factors. Tree improvement therefore, is one of the most viable options to increase productivity of planted forest by ensuring that research and development forms integral part in decision making regarding choice of species and matching to specific sites and producing competitive quality products which is demanded by the markets both locally and internationally.

Following a study which was conducted in 2013 which looked at diversity of planting materials as well as levels of improvements to guarantee sustainable source planting materials, it was discovered that only a limited number of exotic tree species are being utilized for commercial forestry establishment and with very little efforts being directed towards boosting quality issues through tree improvement efforts and accordingly, Forestry Development Trust (FDT) through Tree Improvement Research Working Group (TIRWG) which is a multi-stakeholder grouping approach being tested with partners through inclusive approach which bring sector players from public, private as well as medium and small-scale timber growers. Through this collaborations, some of the constraints hindering sustainable development of a competitive forest sector in Tanzania is utilization of a narrow range of commercial tree species with limited levels of genetic improvement and therefore, it became inevitable to expand on the range of species and hybrid clones of mainly pine and eucalyptus species by establishing diversity of species and clones in site species interaction trials spread through different ecological site types and initially focusing on Southern Highlands where unlike other tree growing areas in the northern part of Tanzania with limited options for further expansion, there are still pockets of land available for plantation establishment with limited food security risks.

The first batch of trials which forms the basis of this report was planted at 4 sites with each site having 3 block of trials namely; Eucalyptus clonal hybrid, Eucalyptus pure species and pine species trials respectively in 4 locations; Kisolanza (Mafinga-Iringa highway), Tanwat (Njombe), Lwangu (on the road to Unilever new factory site (Njombe-Kifanya highway) and lastly Uchindile (Green Resources Limited plantation) these four plantations fall broadly under two broad climatic zones i.e. warm temperate and sub-tropical zones with varying levels of soil fertility, effective rooting depth, average mean annual temperature (MAT) and Mean Annual Precipitation (MAP).

The first measurements of the trials took place after 15 months post planting although the ideal time should have been 12 months post planting targeting mean survival percentages, a key statistic which decision on keeping trials or absolute scrapping is based. Survival assessments and as well as initial height measurements in meters was taken. General tree health as well as stem straightness was assessed. The results were impressive for survival with all the trials achieving over 80% stocking levels which is over the bench mark set in the standard operation procedure (SOP). There were significant differences in mean height and stem form for established species and clonal hybrids at 15 months which although it is

preliminary growth results responding mainly to establishment operations and maintenance (weeding needs) has already started showing different growth levels based on species and levels of improvement as well as sources of the material.

These early results are very encouraging as the main objectives of species diversification and seed sources options for increased productivity in Southern Highlands are already beginning to emerge and better results should be expected as the trials mature. Following the establishment of the first 12 trials, the following successive establishment of similar trials so diversification of genus, species, hybrid types and spread to warmer and lower attitude sites. Location maps showing areas where trials were established can be seen in Figure 1 and list of species and hybrids can be seen in Appendix 1 at the end of the report.

Key words: Pure species, clonal hybrids, seed sources, significant differences, multiple sites, collaborative breeding, Southern Highlands

INTRODUCTION

In response to the recommendations made following a scoping study conducted in Southern Highlands Tanzania in November 2013, the need for further testing of additional exotic tree species targeting predominantly sawn timber and transmission poles markets was initiated following engagements with stakeholders in the forestry sector after recognizing constraints as identified through the study. *Pinus patula* and *Eucalyptus grandis* were and are still the two pre dominant commercial tree species used by all sector players in Tanzania irrespective of the target markets and this puts the entire forestry sector at risk particularly in events of sudden market shift in demands as well emergence of new pests and diseases. In response therefore, Tree Improvement Research Working Group (TIRWG) which is the representative body comprising of members from public, private and associations representing the interests of medium and small scale growers was initiated with facilitation from Forestry Development Trust (FDT) to spearhead the development of multi partner, long-term tree improvement programme for Southern Highlands with a vision to expand to other areas of Tanzania.

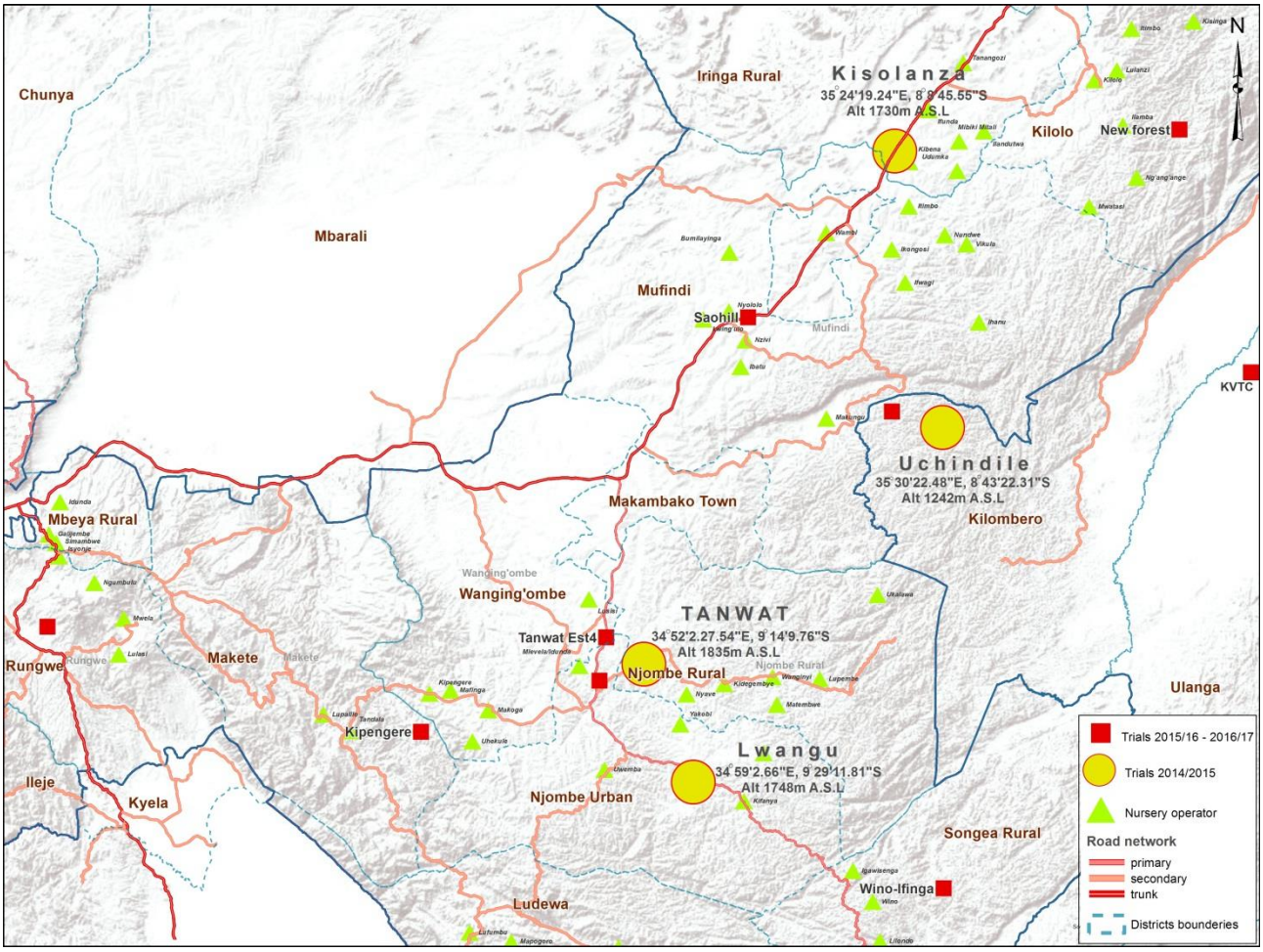
The relevance of tree improvement programme to forestry sector development in Tanzania needs to have three pillars; inclusivity so that tree growers of all scale benefit from production of high value wood products derived from deployment of genetically superior planting material. Investors in the forestry sector will be able secure local as well as international markets for wood products and this leads to competitiveness of the sector in growing Tanzanian economy.

Therefore, as suggested in the Tree Improvement Strategy document developed for Southern Highlands, the first and one of the most important decision that potential investors or small growers in forestry industry will have to make is on choice of species for the market that they are targeting so as tree planting become economically viable business. Generally, Southern Highland landscapes with potential for commercial forestry application fall into two major climatic zones, i.e. warm temperate and sub-tropical tree growing areas and accordingly species and hybrid clones were selected for those site types but most importantly with a strong focus on potential markets and wood qualities required by those specific end use. Both local and international literature available on selection of tree species for similar prevailing climatic conditions was consulted. Changes in market shifts over many years as well as resistance to common diseases and pests, flexibility or robustness of a species to have extensive adaptation range as

well as application in various end products were among some of the factors considered for species inclusion in the test material.

Initially trials were established in collaboration with two large scale private companies (Green Resources & Tanganyika Wattle Co.), private farmer and Catholic dioceses of Njombe and therefore trials were established respectively in Uchindile_2, Tanwat plantation in Njombe, Kisolanza and finally Lwangu near Kifanya in Njombe (Figure 1). Three of the trials were established in areas falling broadly under warm temperate and one in the sub-tropical climatic zones (Upper and lower escarpment).

Figure 1: Map showing trials planted in 2014/2015 and 2015/2016 in Southern Highlands



Each red square represent aggregate of three trials (Eucalyptus clonal hybrid, Eucalyptus pure species and pine species trials) for 2014/2015 planted trials and a red square represent aggregate of four trials (Eucalyptus clonal hybrid, Eucalyptus pure species, pine species trials and Corymbia species trials).

MATERIALS AND METHODS:

Four sites which fall within two distinct climatic zones; warm temperate and subtropical zones in Southern Highlands were selected for trial establishment (Table 1). The specific areas in which trials were sited were decided upon in consultation with partners (Stakeholders) who are all members of Tree Improvement Research Working Group (TIRWG) and therefore offered support in various kinds in ensuring that the trials were established on cost sharing basis.

Trials were planted in blocks of three on each site therefore a total 12 trials were established. The three blocks were; Eucalyptus pure species, Eucalyptus clonal hybrid and Pine species/clonal hybrid trial sites conditions represented in Table 1.

Table 1: Site conditions for the trials established 2014/2015 planting season

Eucalyptus species	**Kisolanza**	**Lwangu**	**Tanwat**	**Uchindile**
Trial Number	FDT/KIS/EPS/01	FDT/LWA/EPS/02	FDT/TAN/EPS/03	FDT/UCH/EPS/04
Location	Kisolanza	Njombe	Njombe	Uchindile
Latitude	S 8^0 09* 05.45"	S 9^0 28* 51.56"	S 9^0 14* 32.49"	S 8^0 43* 29.80"
Longitude	E 35^0 24* 09.64"	E 34^0 59* 09.71"	E 34^0 51* 13.12"	E 35^0 30* 39.57"
Altitude (m)	1730	1735	1845	1230
Mean annual rainfall range (mm)	600-1000	1000-1600	1000-1600	1600-2400
Mean annual temperature(^{0})	17.9-19.4	15.2-18.2	15.2-18.2	16-18.1
Soil Depth (cm)	100 +	100 +	60-100 +	100 +
Planting date	10/02/2015	26/02/2015	6/03/2015	26/03/2015
Eucalyptus clonal hybrids				
Trial Number	FDT/KIS/ECH/01	FDT/LWA/ECH/02	FDT/TAN/ECH/03	FDT/UCH/ECH/04
Location	Kisolanza	Njombe	Njombe	Uchindile
Latitude	S 8^0 09* 05.45"	S 9^0 28* 51.56"	S 9^0 14* 32.49"	S 8^0 43* 29.80"
Longitude	E 35^0 24* 09.64"	E 34^0 59* 09.71"	E 34^0 51* 13.12"	E 35^0 30* 39.57"
Altitude (m)	1730	1735	1845	1230
Mean annual rainfall range (mm)	600-1000	1000-1600	1000-1600	1600-2400
Mean annual temperature (^{0}C)	17.9-19.4	15.2-18.2	15.2-18.2	16-18.1
Soil Depth (cm)	100 +	100 +	60-100 +	100 +
Planting date	10/02/2015	26/02/2015	6/03/2015	26/03/2015

Pine species				
Trial Number	FDT/KIS/PS/01	FDT/LWA/PS/02	FDT/TAN/PS/03	FDT/UCH/PS/04
Latitude	S 8^0 09* 05.45"	S 9^0 28* 51.56"	S 9^0 14* 32.49"	S 8^0 43* 29.80"
Longitude	E 35^0 24* 09.64"	E 34^0 59* 09.71"	E 34^0 51* 13.12"	E 35^0 30* 39.57"
Altitude (m)	1730	1735	1845	1230
Mean annual rainfall range (mm)	600-1000	1000-1600	1000-1600	1600-2400
Mean annual temperature (^{0}C)	17.9-19.4	15.2-18.2	15.2-18.2	16-18.1
Soil Depth (cm)	100 +	100 +	60-100 +	100 +
Planting date	10/02/2015	26/02/2015	6/03/2015	26/03/2015

In total, twenty-six eucalyptus species (Table 2), fifteen eucalyptus clonal hybrids (Table 3) and thirteen pine species (2 clonal hybrids) (Table 4) were selected for testing against locally available control species. Some species were not included in other trials mainly due to land availability issues.

Table 2: List of eucalyptus pure species included in the trials together with their sources

Species	**seed lot no.**	**Source**	**Kisolanza**	**Lwangu**	**Tanwat**	**Uchindile**
E. badjensis		ICFR (RSA)	√	√	√	√
E. benthamii		ICFR (RSA)	√	√	√	
E. grandis		Sappi (RSA)	√			√
E. grandis		Merensky (RSA)	√	√	√	√
E. grandis		*Fort portal (Ug)*	√			
E. grandis		New Forest Co.		√		
E. grandis	GG2	Zimbabwe	√	√	√	√
E. grandis	EUGR2461/1	Local (TTSA	√	√	√	√
E. cloeziana	Eclo076	KLF (RSA)	√	√	√	√
E. cloeziana		Brazil	√	√	√	√
E. dunnii		ICFR (RSA)	√	√	√	√
E. dorigoensis	ER66720	Sappi (RSA	√			
*E. longirostrata*Long13		ICFR (RSA)	√	√	√	√
E. nitens		ICFR (RSA)				
E. paniculata	SFS940	Shell Forestry (SFS)	√	√	√	√

E. saligna		Merensky (RSA)	√	√	√	√
E. smithii	ES68130	Sappi (RSA)	√	√	√	√
E. macurthurii		ICFR (RSA)	√	√	√	√
E. globulus		Shell Forestry (SFS)	√	√	√	√
E. maidenii		Local TTSA	√	√	√	√
E. viminalis	EV68069	Sappi (RSA)	√	√	√	
E. urophylla	Honduras	GRL Nursery	√			
E. urophylla	Brazil	GRL Nursery	√	√	√	√
C. henryi		ICFR (RSA)	√	√	√	√
GC 584_Ctrl		GRL Nursery	√	√	√	√
GC15_Ctrl		GRL Nursery	√	√	√	√
Total number of species + Controls			**26**	**21**	**21**	**20**

Table 3 lists the 15 Eucalyptus clonal hybrids included in the trials (13 *Eucalyptus* clonal hybrids and 2 Eucalyptus seedling hybrids). Clonal hybrids consist of 4 *E.grandis x E. nitens*, 4 *E. grandis x E. urophylla,* 4 *E. grandis x E. camaldulensis*, 1 *E. saligna x E. urophylla* and 2 seedling hybrids (*Urograndis and Camgrandis*). 2 *E. grandis* bulk local seed (TTSA) and *E. grandis* from Zimbabwe were used as controls.

Table 3: List of Eucalyptus clonal hybrids and controls included in the trials together with their sources

Clonal hybrid	**Hybrid Code**	**Source**	**Kisolanza**	**Lwangu**	**Tanwat**	**Uchindile**
E. grandis x E nitens	***GHN_1***	CSIR (RSA)	√	√	√	√
E. grandis x E nitens	***GHN_2***	CSIR (RSA)	√	√	√	
E. grandis x E nitens	***GHN_5***	EZIG (RSA)	√	√	√	√
E. grandis x E nitens	***GHN_6***	CSIR (RSA)	√	√	√	√
E. grandis x E. uropylla	***GHU_1***	CSIR (RSA)	√	√	√	√
E. grandis x E. uropylla	***GHU_4***	CSIR (RSA)	√	√	√	√
E. grandis x E. uropylla	***GU_7***	GRL (Tanz)	√	√	√	√
E. grandis x E. uropylla	***GU_8***	GRL (Tanz)	√	√	√	√
E. saligna x E. uropylla	***SHU_1***	CSIR (RSA)	√	√	√	√
E. grandis x E. camal	***GHC_1***	Mer (RSA)	√	√	√	
E. grandis x E. camal	***GC_15***	GRL (Tanz)	√	√	√	√
E. grandis x E. camal	**GC_584**	GRL (Tanz)	√	√	√	√
E. grandis x E. camal	**GC_581**	GRL (Tanz)	√	√	√	√

E. uroppylla x E. grand	***Urogra***	GRL (Tanz)	√	√	√	√
E. camal x E. grandis	***Camgra***	GRL (Tanz)	√	√	√	√
E. grandis_Ctrl	***E. gran***	Mer (RSA)	√	√	√	√
E. grandis_Ctrl	***E. gran***	ZFC (Zim)	√	√	√	√
Total number of clones + Controls			**17**	**17**	**17**	**15**

Table 4 lists the 5 pine species from 10 sources and 3 clonal hybrids included in the trials. Pinus tecunumannii lower elevation 2 sources, P. maximinoi 3 sources, Pinus oocarpa 1 source, P. caribaea vr. hondurensis 2 sources. Three clonal hybrids of were included in the trials (P. patula x P. tecunumannii, P. elliottii x P. caribaea and P. caribaea x P. elliottii hybrids.

Table 4: List of pine species and clonal hybrids included in the trials together with their sources

Species/clone	**Hybrid Code**	**Source**	**Kisolanza**	**Lwangu**	**Tanwat**	**Uchindile**
P. tecunumannii (L)	*P. tec_Yuc*	GRL (Tanz)	√	√	√	√
P. tecunumannii (L)	*P.tec_Joc*	GRL (Tanz)	√	√	√	√
P. maximinoi	*P. max_Tat*	GRL (Tanz)	√	√	√	√
P. maximinoi	*P. max_Zim*	GRL (Tanz)	√	√	√	√
P. maximinoi	*P. max_Hon*	GRL (Tanz)	√	√	√	√
P. patula	*P. pat_TTSA*	TTSA (Tanz)	√	√	√	√
P. patula	P. pat_Zim	GRL (Tanz)	√	√	√	√
P. oocarpa	*P. ooc_Hon*	GRL (Tanz)	√	√	√	√
P. pat x P. tec (H)	*PHT_1*	EZIG (RSA)	√	√	√	√
P. caribaea vr. Hond.	*PCH_Bra*	GRL (Tanz)	√	√	√	√
P. caribaea vr. Hond.	*PCH_Hon*	CSIR (RSA	√	√	√	√
P. car x P. elli	*Car x ell*	GRL (Tanz)	√	√	√	√
P. elli x P. car	*EHC_1*	CSIR (RSA	√	√	√	√
Total number of species + Controls			**13**	**13**	**13**	**13**

Pre-planting land preparation varied among the four sites with Kisolanza and Lwangu site being the most intensively prepared. The land was ripped and harrowed before manual pitting. Tanwat site was ploughed by tractor between the old stumps of *Acacia mearnsii* before manual pitting. Uchindile site was only manually cleared by hoeing before pitting. Design adopted for these trial series was Randomized Complete Block Design (RCBD) with square plots of 4 x 4 ie 16 trees/plot. Number of replications per trial

varied from 5 to 6 depending on the land made available by collaborating partners. Nitrogen based fertilizer was utilized in all cases at 60g/plant applied immediately after planting. Blanking was done twice with the first one being done 2 weeks post planting and second one 4 weeks after planting. Only manual weeding was applied until canopy closure as chemical/strip weeding was not recommended due to risk associated with chemical drift which could lead to high mortality. Trials were then assessed for growth and survival 15 months after establishment. Only height measurement and stem form (straightness) was assessed as the trials were still too young for diameter at breast height (DBH) to be assessed hence no volume computation was calculated. Subjective score of 8 points was assessed as a measure of straightness, disease incidence was noted and comments on defects on individual trees was noted for analysis. Details for the assessment criteria can be seen in Table 5.

Table 5: Assessment methods and measures used to assess the trial

Trait	Instrument	Method of assessment	Unit/ abbreviation
Height	Vertex Hypsometer	From base to tip of tree	m
Disease	Visual	Subjective score based on severance	0-3
Stem form	Visual	on total bole from base to tip of tree (subjective score)	1-8
Defects	Visual	Forked tree (top, middle or bottom)	FT, FM or FB
		Kinked middle	KM
		Kinked bottom	KB
		Multi-stemmed	MS
		Small	SMA
		Heavy lateral (bottom and middle)	HLB, HLM

The data was analyzed using SAS/STAT software, Version 9.3 of the SAS System for Windows. Copyright © 2002-2003 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA. Data was corrected for fixed effects where significant. Missing trees and those which had broken tops dead but still standing were removed from the data set before analysis. The analysis were performed using the Proc GLM procedure. Tukey's multiple range test was used to indicate significance of difference among species and clonal means for height growth in meters (m) and stem form.

RESULTS

Trial results for the different treatments were ranked by mean heights, survival assessment (N) was also tabulated and expressed as a percentage (Sur_ %), mean treatment stem score with its associated rankings also presented. Table of results are presented for all the four trials in the following order; Eucalyptus pure species, Eucalyptus clonal hybrid and Pine species trials respectively.

EUCALYPTUS PURE SPECIES

Growth and survival results for Kisolanza is presented in Table 6.

Table 6: Mean height eucalyptus species Kisolanza ranked by height (m)

Species	Mean Ht_m	Rank	N	Sur_%	Stem (1-8)	Rank
GC_584_Ctrl	7.15 a	1	80	100	6.47 a	1
E. uro_Bra	6.63 ab	2	79	99	6.34 a	5
E. bad_ICFR	6.48 abc	3	66	83	4.58 ef	24
E. nit_ICFR	6.45 abc	4	64	80	5.85 abc	16
E. ben_ICFR	6.43 bc	5	76	95	5.36 bcd	18
E. sal_Mer	6.41 bc	6	75	94	6.07 ab	10
E. gra_Sappi	6.40 bcd	7	77	96	6.26 a	7
E. uro_Brazil	6.25 bcde	8	79	99	5.77 abc	17
E. gra_Mer	6.21 bcde	9	79	99	6.08 ab	9
E. gra_FortP	6.07 bcde	10	79	99	5.95 abc	12
E. gra_NFC	6.01 bcde	11	79	99	6.24 a	8
E. gra_Zim	6.01 bcde	12	79	99	5.94 abc	14
E. dun_ICFR	5.95 bcde	13	71	89	6.32 a	6
E. smi_Sappi	5.94 bcde	14	69	86	4.84 def	21
GC15_Ctrl	5.86 cde	15	80	100	6.37 a	4
E. glo_SFS	5.82 cde	16	75	94	4.80 def	22
E. vim_Sappi	5.81 cde	17	70	86	4.55 ef	25
E. dor_Sappi	5.69 def	18	77	96	4.97 def	20
E. gra_TTSA	5.58 ef	19	77	96	5.91 abc	15
E. mai _TTSA	5.57 ef	20	77	96	5.94 abc	13
E. mac_ICFR	5.08 gf	21	70	86	4.77 def	23
E.clo_Brazil	4.76 gh	22	77	96	6.46 a	2
C. hen_ICFR	4.74 gh	23	74	93	6.03 ab	11
E. clo_KLF	4.56 ghi	24	79	99	6.42 a	3
E.pan_SFS	4.24 hi	25	78	98	5.28 cde	19
E. lon_ICFR	3.86 i	26	67	84	4.27 f	26
Mean	**5.74**				**5.69**	
SED	**0.030**				**0.029**	

Three cold tolerant eucalyptus of *E. badjensis*, *E. nitens* and *E. benthamii* were ranked in the top 5 species at Kisolanza with percentage survival ranging from 80 to 95%. Stem form being best in *E. nitens* followed by *E. bethamii* and not so impressive in *E. badjensis*. All *Eucalyptus grandis* from 5 different sources were not significantly different for mean height growth with the three afore mentioned species of interest but with better ranking in stem form than the trio. *E. cloeziana* were in the bottom ranking for height growth but with much superior in stem form than all the *E. grandis* and three cold tolerant Eucalyptus (*E. nitens*, *E. badjensis* and *E. benthamii*. Growth and survival results for Lwangu is presented in Table 7.

Table 7: Mean height eucalyptus species Lwangu ranked by height (m)

Species	Mean Ht_m	Rank	N	Sur_%	Stem (1-8)	Rank
E.smi_Sappi	5.68 a	1	70	86	5.89 ghi	17
E.uro_Bra	5.44 ab	2	76	95	6.64 bcde	7
E. glo_SFS	5.35 abc	3	77	96	6.30 cdefg	13
E.bad_ICFR	5.21 abc	4	63	79	5.80 ghi	18
E. sal_Mer	5.08 bcd	5	77	96	6.50 cdef	10
E. nit_ICFR	5.03 bcd	6	75	94	6.74 abcd	5
E. gra_Zim	5.03 bcd	7	78	96	6.77 abc	4
E. gra_TTSA	4.83 cde	8	77	96	6.63 bcde	8
GC 584_Ctrl	4.82 cde	9	78	96	6.62 bcde	9
E. dun_ICFR	4.60 def	10	70	86	6.47 cdef	11
E. mai_TTSA	4.57 def	11	76	95	6.23 defg	14
E. vim_Sappi	4.56 def	12	74	93	5.06 ij	20
E. gra_Mer	4.54 def	13	71	89	6.66 bcde	6
E. ben_ICFR	4.43 ef	14	64	80	5.66 hi	19
GC15 Ctrl	4.40 ef	15	71	89	7.10 ab	2
E. clo_Bra	4.15 fg	16	68	85	7.10 ab	3
E. mac_ICFR	4.07 fg	17	67	84	5.06 j	21
E. clo_KLF	3.83 g	18	67	84	7.19 a	1
C. henryi	3.67 gh	19	75	94	6.48 cdef	12
E. pan_SFS	3.13 hi	20	66	83	6.19 efg	15
E. long_ICFR	2.88 i	21	41	51	6.08 fgh	16
Mean	**4.58**				**6.38**	
SED	**0.030**				**0.026**	

*Eucalyptus smithii, E. globulussspglobulus, E. badjensis*and *E. saligna*were in the top 5 species by height growth ranking in this trial. Stem for was best in this group from *E. saligna*.*E. grandis* were statistically having significantly inferior height growth compared to the top four species. *E. cloeziana* had inferior growth for height but with superior stem straightness. *E. longirostrata* and *E. paniculata* were the poorest species for height growth in the trial at 15 months. Growth and survival results for Tanwat is presented in Table 8**.**

Table 8: Mean height eucalyptus species Tanwat ranked by height (m)

Species	**Mean Ht_m**	**Rank**	**N**	**Sur_%**	**Stem (1-8)**	**Rank**
E. nit_ICFR	4.68 a	1	77	96	6.80 ab	4
E. smi_Sappi	4.53 ab	2	71	89	5.67 fg	20
E. glo_SFS	4.39 abc	3	79	99	6.19 cde	12
E. sal_Mer	4.30 abcd	4	79	99	6.49 abc	9
E. gra_Zim	4.24 abcde	5	78	96	6.69 ab	7
E.uro_Bra	4.23 abcde	6	78	96	6.40 abcd	10
E. ben_ICFR	4.22 abcde	7	75	94	5.82 efg	19
GC584 Ctrl	4.09bcde	8	78	96	6.01efg	15
E. vim_Sappi	4.06 bcde	9	75	94	5.82 efg	11
E. gra_TTSA	4.06 bcde	10	78	96	6.68 ab	8
E. gra_Mer	4.03 bcde	11	78	96	6.85 a	2
E. bad_ICFR	3.92 cdef	12	69	86	5.93 defg	16
E. mai_TTSA	3.84 def	13	78	96	6.84 a	13
GC15	3.82 def	14	78	96	6.85 a	3
E. dun_ICFR	3.77 ef	15	70	88	6.85 a	1
E.mac_ICFR	3.45 fg	16	78	96	5.53 bcd	21
C. hen_ICFR	3.17 g	17	78	96	6.36 bcd	11
E. clo_Bra	3.14 g	18	73	91	6.74 ab	6
E. clo_KLF	3.10 h	19	64	80	6.78 ab	5
E. pan_SFS	2.51	20	57	71	6.11 cdef	14
E. lon_ICFR	1.89	21	44	55	5.83 efg	18
Mean	**3.84**				**6.32**	
SED	**0.027**				**0.023**	

E. nitens was the best performing species on this site but the mean height growth superiority was not significantly different from the immediate low ranked 6 species of *E. smithii*, *E. globulus*ssp*globulus*, *E. saligna*, *E. grandis*, *E. urophylla* and *E. benthamii*. Except for *E. smithii*, all the top ranked species had better stem form. *Eucalyptus dunnii* had a superior stem form on this sites even though it was ranked 15th for average height. *E. cloeziana* dropped in ranking for stem form ie 5th and 6th respectively on this site. Growth and survival results for Tanwat is presented in Table 9.

Table 9: Mean height eucalyptus species Uchindile ranked by height (m)

Species	Mean Ht_m	Rank	N	Sur%	Stem (1-8)	Rank
GC15_ctrl	4.51 a	1	79	99	6.87 a	1
GC584_ctrl	4.47 a	2	78	98	6.60 ab	3
E. smi_Sappi	4.24 ab	3	80	100	5.45 efg	12
E. gra_Sappi	4.09 ab	4	75	94	6.25 abcd	7
E. glo_SFS	4.04 abc	5	74	93	4.84 gh	20
E. sal_Mer	4.00 abcd	6	75	94	5.79 cde	9
E. uro_Bra	3.92 abcde	7	73	92	6.40 abc	5
E. gra_TTSA	3.73 bcdef	8	73	92	6.15 bcd	8
E. clo_Bra	3.71 bcdef	9	73	92	6.77 ab	2
E. nit_ICFR	3.64 bcdef	10	66	83	5.15 fg	19
E. gra_Zim	3.44 bcdefg	11	62	78	6.34 abc	6
E. mac_ICFR	3.39 cdefgh	12	77	96	4.49 h	21
E. bad_ICFR	3.38 defgh	13	52	65	5.40 efg	14
E. dun_ICFR	3.33 efgh	14	80	100	5.68 def	11
E. ben_ICFR	3.17 fgh	15	72	90	5.38 efg	15
E. mai_TTSA	3.11 fghi	16	78	98	5.71 def	10
E. clo_KLF	3.02 ghij	17	67	84	6.55 ab	4
E. gra_Mer	2.90 hij	18	80	100	5.36 efg	16
C. hen_ICFR	2.49 ij	19	67	84	5.28 efg	17
E. pan_SFS	2.43 j	20	75	94	5.19 efg	18
E. lon_ICFR	1.62 k	21	25	32	5.44 efg	13
Mean	**3.53**				**5.78**	
SED	**0.031**				**0.031**	

EUCALYPTUS CLONAL HYBRIDS

Two eucalyptus clonal hybrids (*E. grandis* x *E. camaldulensis*) used as controls were in the top 2 rankings for mean height growth with superior stem form. *E. smithii* and *E. globulus* ssp *globulus* were the only two cold tolerant Eucalyptus ranked in the top 7 for growth parameter assessed with slightly inferior stem form to the *E. grandis x E. camaldulensis* clonal hybrids. *E. cloeziana* from Brazil performed better on this site achieving 9th ranking out of 21 treatments. *E. grandis* from Sappi was the best performer for mean height on this site from other *E. grandis* sources. *Eucalyptus paniculata* and *Eucalyptus longirostrata* were the worst performers on this site.

Growth and survival results for Kisolanza Eucalyptus clonal hybrid trial is presented in Table 10**.**

Table 10: Mean height eucalyptus clonal hybrid Kisolanza ranked by height (m)

Clone	Mean Ht_m	Rank	N	Sur%	Stem (1-8)	Rank
GHN6	7.82 a	1	94	98	6.61 ab	7
GHN2	7.44 b	2	84	88	6.70 a	5
GHN5	6.99 c	3	86	90	6.76 a	3
GHU1	6.92 cd	4	94	98	6.59 ab	9
GHN1	6.77 cde	5	85	87	6.79 a	1
GU8	6.72 cde	6	96	100	6.77 a	2
Cam_gran	6.68 cde	7	93	97	6.29 bc	16
GU7	6.59 de	8	89	93	6.75 a	4
E. gra_TTSA	6.57 de	9	93	97	6.52 ab	12
E, gra_Zim	6.48 e	10	82	85	6.53 ab	11
SHU1	6.46 e	11	93	97	6.60 ab	8
GHU4	6.43 ef	12	94	98	6.52 ab	13
GC581	6.41 ef	13	93	97	6.15 c	17
GC584_Ctrl	6.41 ef	14	95	99	6.31 bc	14
Uro_gran	6.41 ef	15	94	98	6.31 bc	15
GC15_Ctrl	6.08 f	16	94	98	6.56 ab	10
GHC1	5.33 g	17	92	96	6.61 c	6
Mean	**6.61**				**6.55**	
SED	**0.022**				**0.019**	

E. grandis x *E. nitens* clonal hybrid (GHN6) was the top ranked clone for mean height growth significantly better than all other clones included in the trial (P≤ 0.05) with survival percentage of 98 and stem form not significantly different from the best ranked clone for stem form. Four of the five top ranked clones in this site were all *E. grandis x E. nitens* clonal hybrid (GHN2, GHN5, and GHN1 in descending order).

Growth and survival results for Tanwat eucalyptus clonal hybrid trial is presented in Table 11**.**

Table 11: Mean height eucalyptus clonal hybrid Tanwat ranked by height (m)

Clone	Mean Ht_m	Rank	N	Sur%	Stem (1-8)	Rank
GHN6	6.09 a	1	79	99	6.82 abc	8
GHN5	5.51 b	2	80	100	6.69 abcd	13
GNH2	5.34 b	3	77	96	6.85 abc	5
GHN1	5.35 b	4	80	100	6.91 a	1
Uro_gra	4.62 c	5	79	99	6.52 cde	15
GU8	4.45 cd	6	78	98	6.86 ab	4
Cam_gra	4.42 cde	7	80	100	6.29 e	17
E. gra_Zim	4.38 cde	8	78	98	6.88 ab	3
GC584	4.31 cdef	9	75	94	6.46 de	16
GU7	4.30 cdef	10	78	98	6.84 abc	6
GC581	4.28 cdef	11	80	100	6.84 abc	7
SHU1	4.20 def	12	80	100	6.75 abcd	11
GHU4	4.15 def	13	79	99	6.79 abcd	9
GC15	4.07 ef	14	78	98	6.90 ab	2
GHU1	3.95 f	15	78	98	6.75 abcd	12
E. gra_Mer	3.94 f	16	77	96	6.57 bcde	14
GHC1	3.36 g	17	76	95	6.76 abcd	10
Mean	**4.52**				**6.73**	
SED	**0.026**				**0.017**	

E. grandis x *E. nitens* clonal hybrid (*GHN6*) was the top ranked clone for mean height growth significantly better than all other clones included in the trial (P≤0.05) with survival percentage of 99 and stem form not significantly different from the best ranked clone for stem form. This was then followed by three hybrid clones *GHN5*, *GHN2* and *GHN1* in descending order respectively registering survival percentage ranging from 96-100%. *E. grandis x E. urophylla*7 and 8 was ranked 10th and 6th respectively with no significant differences between the for height growth. Growth and survival results for Lwangu eucalyptus clonal hybrid trial is presented in Table 12**.**

Table 12: Mean height eucalyptus clonal hybrid Lwangu ranked by height (m)

Clone	Mean Ht_m	Rank	N	Sur%	Stem (1-8)	Rank
GHN5	6.25 a	1	95	99	7.03 a	2
GHN6	6.02 ab	2	95	99	6.88 abc	9
GHN2	6.01 ab	3	96	100	6.93 ab	5
GHN1	5.88 bc	4	96	100	6.93 ab	6
GC584	5.55 cd	5	95	99	6.82 abcd	13
Cam_gra	5.84 cd	6	93	97	6.55 d	17
E. gra_Zim	5.53 d	7	94	98	6.88 abc	10
Uro_gra	5.46 de	8	94	98	6.70 bcd	15
SHU1	5.33 def	9	93	97	6.92 abc	8
GU8	5.23 defg	10	92	96	7.01 a	3
GHU1	5.16 efg	11	96	100	6.84 abc	12
GHU4	5.16 efg	12	96	100	6.81 abcd	14
GC581	5.12 efg	13	96	100	6.87 abc	11
GU7	4.98 fgh	14	95	99	6.94 a	4
GC15	4.92 gh	15	96	100	7.09 a	1
E. gra_Mer	4.72 h	16	94	98	6.70 bcd	16
GCH1	4.71 h	17	93	97	6.92 ab	7
Mean	**4.58**				**6.38**	
SED	**0.030**				**0.026**	

E. grandis x *E. nitens* clonal hybrid (*GHN5*) was the top ranked clone for mean height growth but not significantly better than GHN6 and GHN2 the second and the third ranked clonal hybrid on this site. It recorded a survival percentage of 99% and stem form not significantly different from the best ranked clone for stem form. Growth and survival results for UchindileEucalyptus clonal hybrid trial is presented in Table 13**.**

Table 13: Mean height eucalyptus clonal hybrid Uchindile ranked by height (m)

Clone	Mean Ht_m	Rank	N	Sur%	Stem (1-8)	Rank
GHN6	6.46 a	1	80	100	6.75 abc	4
Cam_gra	5.74 b	2	78	98	6.46 bcde	11
GHN5	5.72 b	3	80	100	6.56 abcde	7
GHU4	5.71 bc	4	80	100	6.63 abcd	5
Uro_gra	5.62 bc	5	77	96	6.36 cde	13
GC584_Ctrl	5.61 bc	6	80	100	6.51 bcde	9
GU7	5.41 bcd	7	79	99	6.92 a	1
GC15_Ctrl	5.40 bcd	8	80	100	6.85 ab	2
GHU1	5.31 bcde	9	80	100	6.61 abcde	6
E. gra_Zim	5.23 cde	10	78	98	6.42 cde	12
GHN1	4.96 def	11	79	99	6.48 bcde	10
GU8	4.92 def	12	79	99	6.76 abc	3
E. gra_Mer	4.89 ef	13	80	100	6.21 e	15
GC581	4.65 fg	14	79	99	6.53 abcde	8
SHU1	4.34 g	15	78	98	6.30 de	14
Mean	**5.33**				**6.56**	
SED	**0.030**				**0.022**	

E. grandis x *E. nitens* clonal hybrid (*GHN6*) was the top ranked clone for mean height growth significantly better than all other clones included in the trial **(P≤0.05)** with survival percentage of 100% and stem form not significantly different from the best ranked clone for stem form. *Cam_grandis* seedling hybrid was second ranked seedling hybrid with no significant difference with clonal hybrids ranked from 3rd to 9th position.

PINE SPECIES AND CLONAL HYBRIDS

Growth and survival results for Kisolanza Pine species trial in Table 14**.**

Table 14: Mean height pine species Kisolanza ranked by height (m)

Species	Mean Ht_m	Rank	N	Sur%	Stem (1-8)	Rank
Tec_Yuc	2.64 a	1	96	100	6.56 a	2
Max_Tat	2.47 a	2	96	100	6.45 a	6
Max_Zim	2.26 b	3	94	98	6.46 a	5
Pat_TTSA	2.05 bc	4	92	96	6.36 a	8
Pat_Zim	2.02 cd	5	96	100	6.44 a	7
Oor_Hon	1.95 cde	6	96	100	5.69 b	13
Max_Hon	1.92 cde	7	89	93	6.13 ab	10
PHT1_Ezi	1.91 cde	8	88	92	6.46 a	3
Tec_Joc	1.84 de	9	95	99	5.75 b	11
PCH_Bra	1.79 cf	10	93	97	6.15 ab	9
PCH_Hon	1.62 fg	11	92	96	5.75 b	12
EHC1_CSIR	1.52 g	12	83	86	6.46 a	4
CarxEllio_Br	1.42 g	13	94	98	6.67 a	1
Mean	**1.96**				**6.26**	
SED	**0.015**				**0.033**	

Pinus tecunumanii (Lower Elevation) and *Pinus maximinoi* were the two top ranked species and are significantly (P≤ 0.05) better than all other species and clonal hybrid in the trial for mean height growth. The two species in the trial had 100% survival. *Pinus caribaea* var. *hondurensis* (PCH) were significantly inferior in in growth compared to *P. tecunumanii*, *P. maximinoi* and *P. patula* on this site. Growth and survival results for Lwangu Pine species trial in Table 15**.**

Table 15: Mean Height Pine species Lwangu ranked by height (m)

Species	Mean Ht_m	Rank	N	Sur%	Stem (1-8)	Rank
Tec_Yuc	2.18 a	1	90	94	6.74 a	1
Max_Zim	1.99 b	2	91	95	6.54 abcd	4
Max_Tat	1.90 b	3	92	96	6.45 abcd	5

Max_Hon	1.69 c	4	89	93	6.27 cde	9
Pat_Zim	1.58 cd	5	95	99	6.59 abc	3
PHT1_Ezi	1.56 cd	6	86	90	6.68 ab	2
Pat_TTSA	1.56 cd	7	95	99	6.24 cde	10
Tec_Joc	1.53 cd	8	88	92	6.16 de	12
Ooc_Hon	1.49 d	9	90	94	6.18 de	11
PCH_Bra	1.46 de	10	94	98	6.30 bcde	8
PCH_Hon	1.30 e	11	88	92	5.96 e	13
EHC1_CSIR	1.30 e	12	92	96	6.41 abcd	7
Carxelli_Br	1.10 f	13	91	95	6.42 abcd	6
Mean	**1.59**				**6.38**	
SED	**0.013**				**0.024**	

P. tecunumanii was the top ranked species for mean height growth and has performed significantly better than other species for mean height growth **(P≤ 0.05).**It is also top ranked for stem form although not significantly better than the 2nd and the 3rd ranked species for stem form.Growth and survival results for Tanwat Pine species trial in Table 16**.**

Table 16: Mean height pine species Tanwat ranked by height (m)

Species	Mean Ht_m	Rank	N	Sur%	Stem (1-8)	Rank
Max_Zim	1.64 a	1	80	100	6.51 b	10
Tec_Yuc	1.63 a	2	80	100	6.76 ab	2
Max_Tat	1.57 ab	3	78	98	6.56 ab	8
Pat_Zim	1.47 bc	4	78	98	6.73 ab	4
Pat_TTSA	1.34 cd	5	80	100	6.56 ab	9
Max_Hon	1.32 d	6	79	99	6.57 ab	7
Ooc_Hon	1.32 d	7	80	100	5.85 c	13
PHT1_Ezi	1.18 e	8	79	99	6.57 ab	6
PCH_Bra	1.17 e	9	77	96	6.58 ab	5
PCH_Hon	1.17 e	10	78	98	6.50 b	11
Tec_Joc	1.44 e	11	76	95	5.96 c	12

EHC1_CSIR	0.96 f	12	78	98	6.91 a	1
Car x Elli_Braz	0.93 f	13	80	100	6.75 ab	3
Mean	**1.30**				**6.52**	
SED	**0.011**				**0.024**	

P. maximinoi was the top ranked species in this trial but not significantly better than the 2nd and 3rd ranked species. *P. caribaea* were all in the bottom half of species ranking. Growth and survival results for Uchindile Pine species trial in Table 17.

Table 17: Mean height pine species Uchindile ranked by height (m)

Species	Mean Ht_m	Rank	N	Sur%	Stem (1-8)	Rank
Tec_Yuc	2.30 a	1	96	100	6.69 a	5
Max_Tat	1.94 b	2	96	100	6.60 a	7
Max_Hon	1.88 b	3	93	97	6.81 a	1
Ooc_Hon	1.80 bc	4	93	97	6.32 cd	11
Max_Zim	1.78 bc	5	95	99	6.72 ab	3
PHT1_Ezi	1.77 bc	6	90	94	6.61 abc	6
Tec_Joc	1.70 cd	7	94	98	6.22 d	12
PCH_Bra	1.66 cd	8	95	99	6.36 abc	10
Pat_TTSA	1.65 cd	9	96	100	6.56 abcd	8
Pat_Zim	1.64 cd	10	89	93	6.74 abcd	2
PCH_Hon	1.57 d	11	96	100	5.85 d	13
EHC1_CSIR	1.21 e	12	88	92	6.71 a	4
CarxElli_Bra	1.05 e	13	96	100	6.49 abcd	9
Mean	**1.69**				**6.51**	
SED	**0.013**				**0.022**	

P. tecunumanii was the top ranked species for mean height growth and has performed significantly better than other species for mean height growth (P≤0.05). It attained 100% survival rates and ranked 5th for stem form. It significantly outperformed the 2nd and the 3rd ranked species for mean height

DISCUSSION

Overall survival after 15 months have been extremely encouraging and this can be attributed to extra attention put in the initiation phase/establishment phase that resulted in high survival numbers. Pines at a species level have higher survival percentage than Eucalyptus clonal hybrids and Eucalyptus species this is mainly because they are not susceptible to termite destruction than the rest of the species and clonal hybrids which are vulnerable.

There are significant differences in species performance at 15 months for both height and stem form and this is encouraging signs particularly for useful information that will come in from 4 to 5 yrs (Clonal hybrids eucalyptus and Eucalyptus species) and slightly longer time for Pine species.

For Eucalyptus clonal hybrid, *E. grandis x E. nitens* have shown early growth superiority compared to other clones in the high altitude sites (warm temperate sites). Future breeding efforts should be directed towards acquisition, testing more cold tolerant hybrids like *E. grandis x E. globulus*, *E. grandis x E. badjensis*, *E. grandis x E. benthamii* etc. Similar crosses with *Eucalyptus saligna* should also be attempted as it has shown that *E. saligna* x *E. urophylla (SxU 1)* included in the trial is showing promise and this is mainly attributed the diseases tolerance attributed to paternal species *E. urophylla*.

For the subtropical zones,*E. grandis x E. camaldulensis*, *E. grandis x E. urophylla*, *E. grandis x E. tereticornis* and other hybrid combinations should be adequately tested especially with materials of known wood properties which have shown signs of disease resistance. This will play a very important role as intervention moves to warmer and drier low lying areas located along the coast and central Tanzania.

Cold tolerant Eucalyptus are showing promise in the warm temperate zones and efforts should start being directed towards having breeding materials available for testing provenances (and progenies) and building a breeding base (breeding populations). *E. nitens*, *E. badjensis*, *E. benthamii*, *E. smithii* and *E. dunnii* are some of the species recommended for immediate action. *E. cloeziana*, *E. urophylla*, *E. saligna*, *E. tereticornis* and *E. camaldulensis* are priority species for the subtropical zones. Attempts should be made to try at earliest convenience to establish provenance/progeny trials of the species showing promise.

Pine species showing great potential in Southern Highlands are *P. maximinoi* and *P. tecunumanii*. These should be developed in addition to *P. patula*, *P. elloittii*, *P. taeda*, *P. kesiya*, *P. oorcapa* and *P. caribaea*. Hybrid material especially of *P.patula x P. tecunumanii* (Lower elevation) should be prioritized as it will have potential for commercial deployment in drier and shallower soils which limits (altitude less than 1500m above sea level) vigorous growth of *P. patula* but also has the capability of resisting *fusarium circinatum* (nursery fungal pathogen)

CONCLUSION AND RECOMMENDATIONS

Fifteen-month growth assessment results, although too early, have shown very good prospects and therefore with manpower and financial resources being made available, it should be planned annually and parameters for assessment to be extended to include diameter at breast height (dbh) so that tree volumes can be calculated which will have significant impact on growth ranking (productivity) of the species on different sites. These sets of results have demonstrated that it is possible for forestry sector to be organized and members start contributing towards research and development activities with incentives to increase productivity of their forestry biological assets. Establishment of species/clonal trials to be extended in future to low altitude warmer and wetter sites and hotter and drier sites as this is not covered adequately in current established trials.

It should also be noted that these are preliminary growth results (15 months) and as much as it looks encouraging caution should be taken in the interpretation of these results before making any financial commitments/investment into planting stock as demonstrated in these early sets of growth data. However, survival percentages which is expected to remain stable is a good sign for stakeholders to have faith in the trials to begin delivering scientifically proven information to guide partners in implementing operations which will lead to competitiveness, inclusive and resilience sector. At this early growth years, partners should start looking critically into where they source germplasm for plantation establishment as seed sources performance has been clearly shown in these early results to influence growth performances. Stakeholders are however advised to be patient by allowing adequate time for these materials to be tested in diverse environments and wood properties studies to be ascertained upon trial completion for suitability for different end markets both locally and internationally. However, the impressive survival rates which main objective for this early reporting gives the team confidence in the reliability of growth information to come as the trials mature.

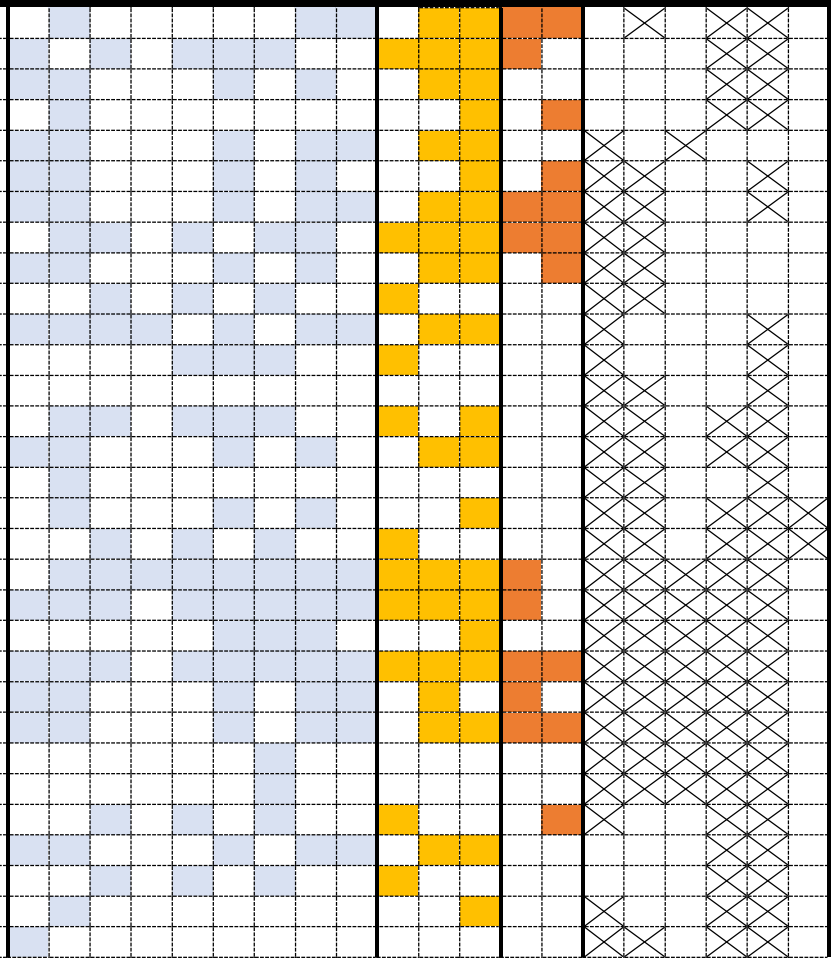
ACKNOWLEDGEMENTS

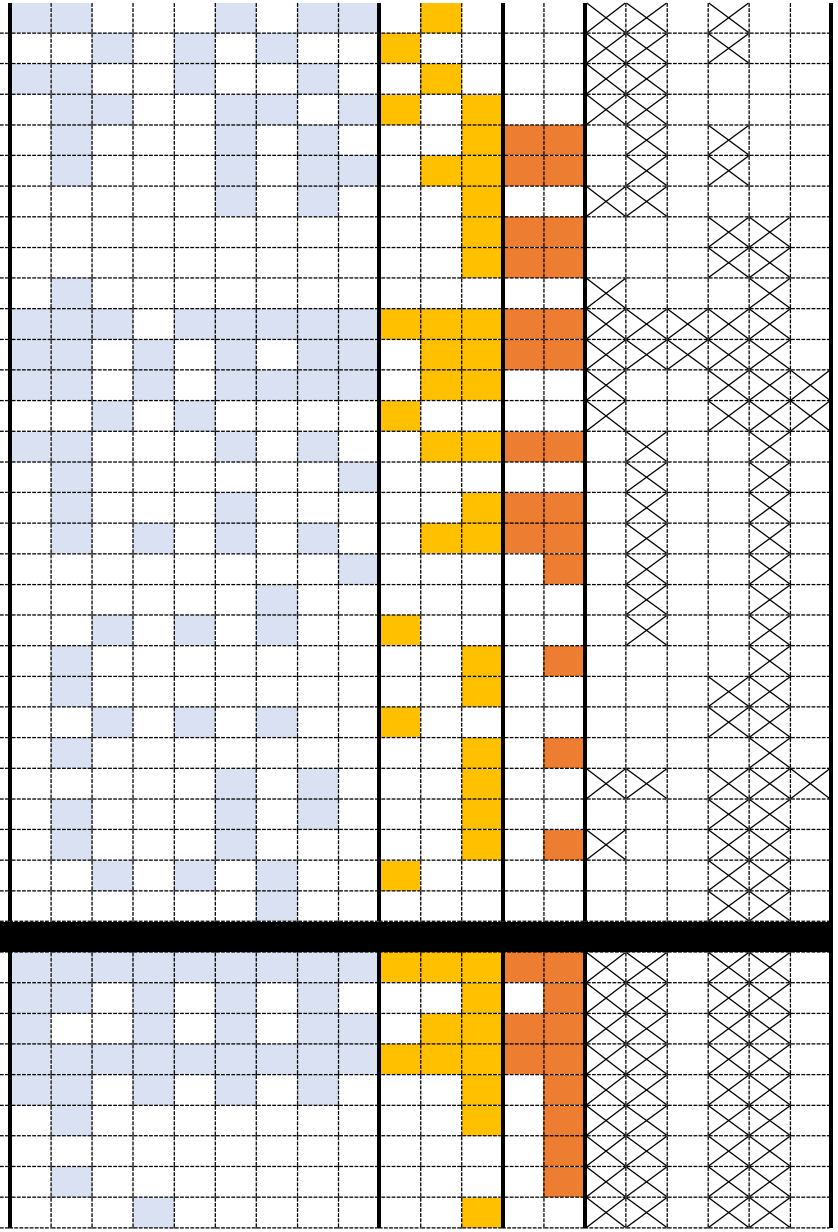
Partners who were involved in the implementation phase of these trial series are acknowledged for their positive contribution which enabled us to have results to share with sector players at 15 months following implementation. Although attempts will be made not to mention individuals within the institutions, a few will be mentioned by names as their comments and generous offer for use of their established facilities contributed immensely to the successful establishment of these early trials respectively.

Braham Goswami managing director for TANWAT for giving FDT access to land but most importantly strong support for research and development in Tanzania and neighbouring countries in the region where forest productivity is lagging behind developed countries by about 45 years and no time should then be wasted in implementing research activities and TANWAT is willing to work with FDT with or without other partners as well as sharing costs of implementation. To date, TANWAT in partnership with FDT and a total of 7 species trials and 2 breeding populations have been established in their land holding and purely on a cost sharing basis. Roselyne Mariki, former managing director for Green Resources Limited and Sao-Hill industries, for allowing FDT full access for utilization of Makungu nursery for raising seedlings and being used as a holding nursery for imported clonal hybrid material from South Africa. This made it possible for FDT to have enough planting materials for the establishment of the first 12 species and clonal hybrid trials free of charge in the first planting season ie 2014/2015 planting season with only 3 months between initial planning and trial establishment. To date Green Resources have in their land holding 7 species and clonal hybrid trials but only 3 trials are covered in this report. Others include owners of Kisolanza farm, Njombe catholic dioceses, Tanzania Tree Seed Agency (TTSA) and Tanzanian Forestry Research Institute (TAFORI) timely processing documents for germplasm importation and provision of one researcher to work with FDT team on a full time basis respectively. Tanzanian Forestry Services (TFS), Sokoine University of Agriculture (SUA) and other forestry colleges for being at our disposal when we needed guidance especially from inception of the programme in Morogoro in late 2013. Tree Improvement Research Working Group (TIRWG) for making valuable recommendations regarding data collection for next round of reporting and recommendation on how to approach institutional arrangement for funding tree improvement activities in Tanzania. FDT advisory panel members for constantly making recommendation on way forward with tree improvement operations particularly on the need to spread to other warmer and drier areas of Tanzania where a lot of deforestation is taking place. A move is being made currently that will ensure that recommendations made are implemented at a scale which acceptable taking into account challenges regarding financial sustainability of tree improvement programme which is funded by sector players. To the young graduates and mature field team for hard work which enabled the survival to be very high in all the trial sites and the learning based on being able to listen and follow step by step guidance which is key for development of skill sets required in implementation of research activities. You are encouraged to maintain the high standard and good team work which at times are executed under difficult circumstances but above all being able to listen attentively to instructions and always asking questions about why those activities/ operations are being implemented. Finally, Gatsby Africa and DFID for funding the program with a clear vision of transforming the forestry sector with specific emphasis in assisting small growers improve their income through advancing tree improvement as one of the ways to enhancing forestry productivity in Tanzania. There will always be challenges but your active involvement with the team on a regular basis has been the motivation behind this team efforts which within a short period of time boasts of showing you practically what has been done with the financial support and stakeholders equally appreciate the work being done.

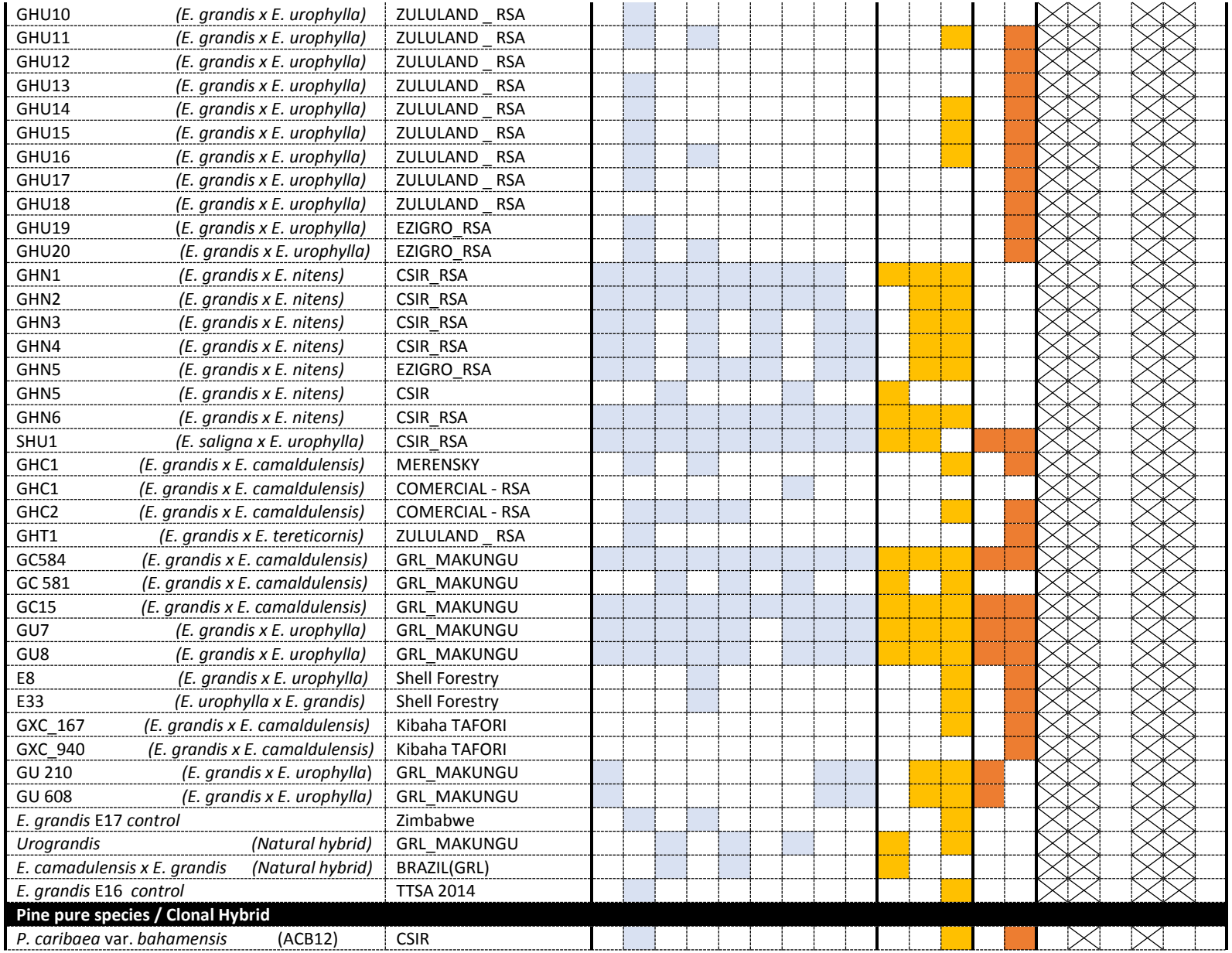
APPENDIX I

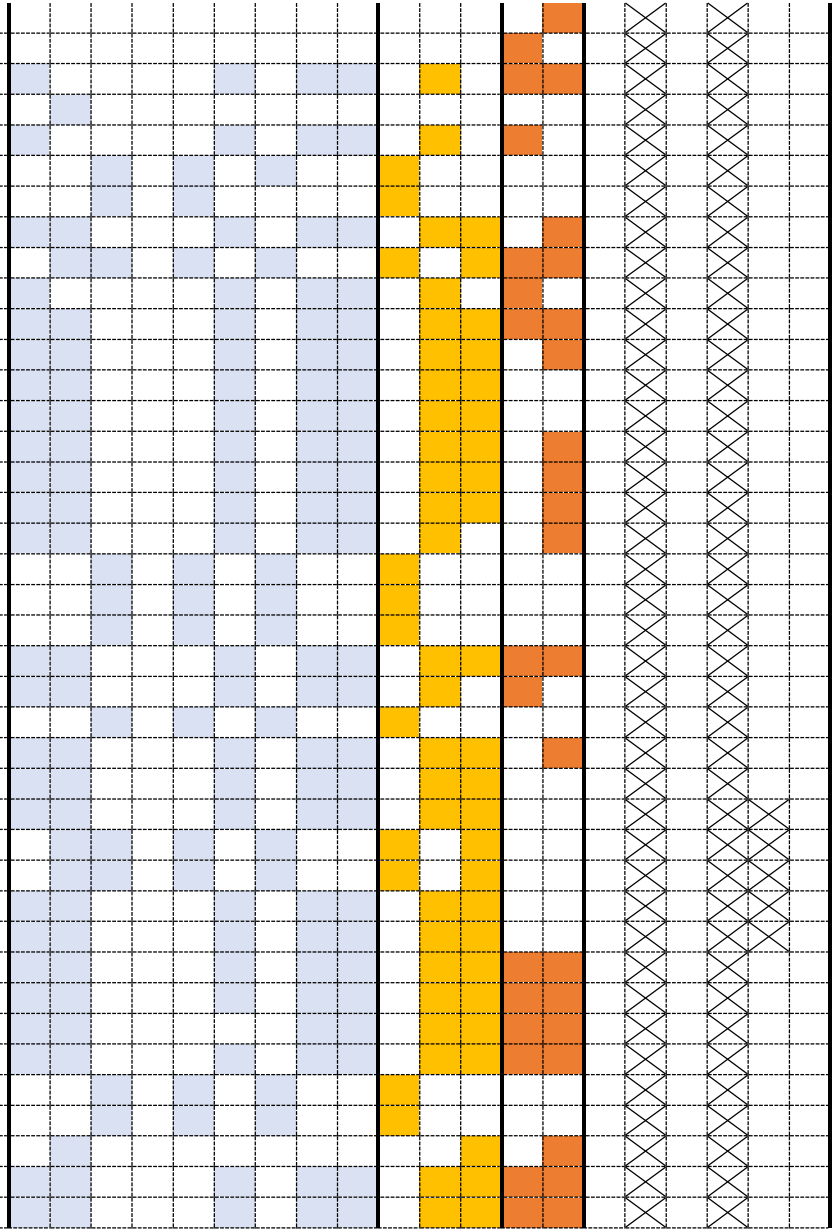
List of Genus, species and clonal hybrid trials established by FDT in collaboration with partners over three planting seasons, i.e. 2014/2015, 2015/2016 and 2016/2017 planting seasons.

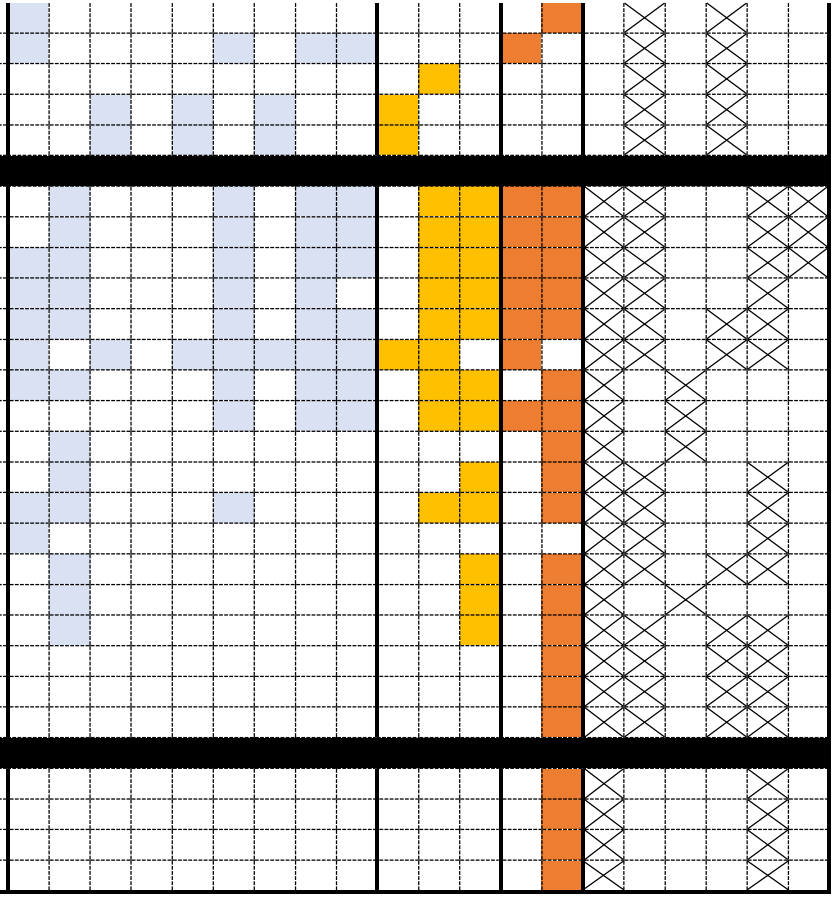
Eucalyptus		
E. alba	CSIRO-Australia	
E. benthamii	ICFR	
E. benthamii	CSIRO-Australia	
E. biturbinata	CSIRO-Australia	
E. botryoides	ZFC	
E. camaldulensis	ZFC	
E. camaldulensis	TTSA-Igumbilo	
E. cloeziana	KLF	
E. cloeziana	ZFC	
E. cloeziana	Brazil (GRL)	
E. dunnii	SAPPI	
E. dunnii	ICFR	
E. globulus ssp. *bicostata*	CSIRO-Australia	
E. globulus ssp. *maidenii*	TTSA-Ifunda (2014)	
E. globulus ssp. *maidenii*	CSIRO-Australia	
E. globulus ssp. *pseudoglobulus*	CSIRO-Australia	
E. globulus ssp. *globulus*	CSIRO-Australia	
E. globulus ssp. *globulus*	Shell Forestry	
E. grandis	TTSA 2014	
E. grandis	Zimbambwe	
E. grandis	New forestry (RSA)	
E. grandis	Merensky low split 2013	
E. grandis	Mondi-Panbult	
E. grandis	Mondi -7oaks	
E. grandis	SAPPI	
E. grandis	Fort Portal (GRL)	
E. longirostrata	ICFR	
E. macarthurii	SAPPI	
E. macarthurii	ICFR	
E. microcorys	CSIRO-Australia	
E. maidenii	TTSA	

E. nitens		SAPPI	
E. nitens		ICFR	
E. paniculata		SFS	
E. paniculata		Shell Forestry	
E. pellita		SAPPI	
E. pellita		TTSA-KIROKA	
E. pilularis		CSIRO-Australia	
E. punctata		CSIRO-Australia	
E. resinifera		CSIRO-Australia	
E. robusta		TTSA-Kihanga	
E. saligna		Merensky_RSA	
E. saligna		Mondi-7oaks	
E. smithii		SAPPI	
E. smithii		ICFR	
E. tereticornis		Shell Forestry	
E. tereticornis		SF 1019	
E. tereticornis		TTSA-DODOMA	
E. urophylla		SAPPI	
E. urophylla		CSIR ex-boschoek	
E. urophylla		Honduras (GRL)	
E. urophylla		Brazil (GRL)	
E. argophloea		Nseleni-RSA	
E. badjensis		CSIRO-Australia	
E. badjensis		ICFR	
E. coolabah		CSIRO-Australia	
E. globulus ssp. *globulus*		CSIRO-Australia	
E. badjensis		SAPPI	
Mysore Gum (E.tereticornis x E. camaldulensis)		Shell Forestry	
E. viminalis		SAPPI	
E. dorrigoensis		ICFR	
Eucalyptus Clonal Hybrid			
GHU1	(*E. grandis x E. urophylla*)	CSIR_RSA	
GHU2	*(E. grandis x E. urophylla)*	CSIR_RSA	
GHU3	*(E. grandis x E. urophylla)*	CSIR_RSA	
GHU4	*(E. grandis x E. urophylla)*	CSIR_RSA	
GHU5	*(E. grandis x E. urophylla)*	CSIR_RSA	
GHU6	*(E. grandis x E. urophylla)*	ZULULAND _ RSA	
GHU7	*(E. grandis x E. urophylla)*	ZULULAND _ RSA	
GHU8	*(E. grandis x E. urophylla)*	ZULULAND _ RSA	
GHU9	*(E. grandis x E. urophylla)*	ZULULAND _ RSA	

GHU10	*(E. grandis x E. urophylla)*	ZULULAND _ RSA
GHU11	*(E. grandis x E. urophylla)*	ZULULAND _ RSA
GHU12	*(E. grandis x E. urophylla)*	ZULULAND _ RSA
GHU13	*(E. grandis x E. urophylla)*	ZULULAND _ RSA
GHU14	*(E. grandis x E. urophylla)*	ZULULAND _ RSA
GHU15	*(E. grandis x E. urophylla)*	ZULULAND _ RSA
GHU16	*(E. grandis x E. urophylla)*	ZULULAND _ RSA
GHU17	*(E. grandis x E. urophylla)*	ZULULAND _ RSA
GHU18	*(E. grandis x E. urophylla)*	ZULULAND _ RSA
GHU19	(*E. grandis x E. urophylla)*	EZIGRO_RSA
GHU20	*(E. grandis x E. urophylla)*	EZIGRO_RSA
GHN1	*(E. grandis x E. nitens)*	CSIR_RSA
GHN2	*(E. grandis x E. nitens)*	CSIR_RSA
GHN3	*(E. grandis x E. nitens)*	CSIR_RSA
GHN4	*(E. grandis x E. nitens)*	CSIR_RSA
GHN5	*(E. grandis x E. nitens)*	EZIGRO_RSA
GHN5	*(E. grandis x E. nitens)*	CSIR
GHN6	*(E. grandis x E. nitens)*	CSIR_RSA
SHU1	*(E. saligna x E. urophylla)*	CSIR_RSA
GHC1	*(E. grandis x E. camaldulensis)*	MERENSKY
GHC1	*(E. grandis x E. camaldulensis)*	COMERCIAL - RSA
GHC2	*(E. grandis x E. camaldulensis)*	COMERCIAL - RSA
GHT1	*(E. grandis x E. tereticornis)*	ZULULAND _ RSA
GC584	*(E. grandis x E. camaldulensis)*	GRL_MAKUNGU
GC 581	*(E. grandis x E. camaldulensis)*	GRL_MAKUNGU
GC15	*(E. grandis x E. camaldulensis)*	GRL_MAKUNGU
GU7	*(E. grandis x E. urophylla)*	GRL_MAKUNGU
GU8	*(E. grandis x E. urophylla)*	GRL_MAKUNGU
E8	*(E. grandis x E. urophylla)*	Shell Forestry
E33	*(E. urophylla x E. grandis)*	Shell Forestry
GXC_167	*(E. grandis x E. camaldulensis)*	Kibaha TAFORI
GXC_940	*(E. grandis x E. camaldulensis)*	Kibaha TAFORI
GU 210	*(E. grandis x E. urophylla*)	GRL_MAKUNGU
GU 608	*(E. grandis x E. urophylla)*	GRL_MAKUNGU
E. grandis E17 *control*		Zimbabwe
Urograndis	*(Natural hybrid)*	GRL_MAKUNGU
E. camadulensis x E. grandis	*(Natural hybrid)*	BRAZIL(GRL)
E. grandis E16 *control*		TTSA 2014
Pine pure species / Clonal Hybrid		
P. caribaea var. *bahamensis*	(ACB12)	CSIR



P. caribaea var. *bahamensis* (ACH348)	CSIR	
P. caribaea var *hondurensis*	Zimbabwe	
P. caribaea var. *hondurensis* (Brazil)	Brazil (GRL - 2016)	
P. caribaea var. hondurensis(Honduras)	Gauntemala (GRL-2016)	
P. caribaea var *hondurensis*	Honduras	
P. caribaea var *hondurensis*	Honduras (GRL-2014)	
P. caribaea var hondurensis	Brazil (GRL - 2014)	
P. elliottii x *P. caribaea*	Australia(New forest)	
P. elliottii x *P. caribaea*	CSIR	
P. elliottii x *P. caribaea* var. homd.	Honduras	
P. elliottii	RSA-Ezigrow	
P. gregii (North)	YORK TIMBERS	
P. gregii (South)	YORK TIMBERS	
P. gregii (South)	SAPPI	
P. kesiya (P8)	ZFC	
P. kesiya (P15)	ZFC	
P. maximinoi	Zimbambwe (GRL-2016)	
P. maximinoi	Honduras (GRL-2016)	
P. maximinoi	Honduras (GRL - 2014)	
P. maximinoi	Zimbabwe (GRL - 2014)	
P. maximinoi	Tatumbla (GRL - 2014)	
P. oocarpa	ZFC	
P. oocarpa	Honduras (GRL-2016)	
P. oocarpa	GRL_MAKUNGU	
P. patula x P. tecunumanii (high) - PHAT1	RSA-Ezigrow	
P. patula x *P. tecunumanii* (low) - PHAT2	RSA-Ezigrow	
P. patula	YORK TIMBERS	
P. patula	TTSA (Control)	
P. patula	Zimbabwe (Control)	
P. patula C	SAPPI	
P. patula	Ezygro	
P. taeda	YORK TIMBERS	
P. tecunumanii	(KLF)	
P. tecunumanii	Honduras (GRL-2016)	
P. tecunumanii	Zimbambwe (GRL-2016)	
P.tecunumanii (Yukul)	GRL_MAKUNGU	
P. tecunumanii (Jocon)	GRL_MAKUNGU	
P. elliottii x *P. caribaea* var. homd.	RSA-Ezigrow	
P. taeda	RSA-Ezigrow	
P. taeda	SAPPI-USUTU	

P. caribaea var. *caribaea* (PCC232/PCC118)	CSIR	
P. elliottii. x *P. caribaea* (PEHC1)	CSIRO	
P. elliottii x *P. caribaea* (CHC1)	CSIRO	
P. caribaea x *P. elliottii*	GRL_MAKUNGU	
P. patula x P. tecunumanii (low)	Commercial - RSA	
Corymbia Species / Clonal Hybrid		
C. citriodora	ZFC	
C. citriodora	TTSA-(Mkundi)	
C. citriodora ssp citriodora	CSIRO-Australia	
C. citriodora ssp variegata	CSIRO-Australia	
C. henryi	CSIRO-Australia	
C. henryii	ICFR	
C. maculata	TTSA-Kibwabwa	
C. maculata	CSIRO-Australia	
C. maculata	RSA	
C. torreliana	RSA-CRI	
C. torreliana	Shell forest	
C. citriodora	TZ	
C. henryi	KWAMBO-ZDL	
C. maculata	ZFC	
C. torelliana x C. henryii (Seedling hybrid)	Zululand_RSA	
C. torelliana x C. henryii (Clonal hybrid)	Zululand_RSA	
C. torelliana x C. henryii (Clonal hybrid)	Zululand_RSA	
C. torelliana x C. henryii (Clonal hybrid)	Zululand_RSA	
Casuarina		
C. equisetifolia	ST. Lucia - RSA	
C. equisetifolia	Kwambonambi - RSA	
C. equisetifolia	TTSA	
C. junghuhniana	ZFC - Zimbabwe	