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Provenance Variation in *Gmelina arborea*

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မူရင်းဒေသအမျိုးမျိုးမှ ယမနေသစ်မျိုး၏ ရှင်သန်ကြီးထွားမှုကို နှိုင်းယှဉ်လေ့လာခြင်း

ဦးသိန်းထွေး၊ B.Sc. (Forestry) ၊ ဦးစီးအရာရှိ
သစ်တောသုတေသနဌာန၊ရေဆင်း

စာတမ်းအကျဉ်းချုပ်

ယမနေသည် အကြီးမြန်သစ်မျိုးဖြစ်၍ ကျွန်းကဲ့သို့သော အလင်းကြိုက် သစ်မျိုးလည်း ဖြစ်ပါသည်။ နှစ်သက်သော အခြေအနေရှိပါက အချိန်တိုအတွင်း အသုံးပြုနိုင်သော အရွယ်သို့ ရောက်ရှိနိုင်သဖြင့် ဘရာဇီး၊ အိန္ဒိယ၊ မလေးရှား၊ ဖိလစ်ပိုင်၊ ယိုးဒယားနှင့် ကမ္ဘာ့နိုင်ငံအတော်များများတွင် ယမနေစိုက်ခင်းများ ကျယ်ကျယ်ပြန့်ပြန့် တည်ထောင်လျက်ရှိပါသည်။ ဤစာတမ်းတွင် အဆိုပါ အကြီးမြန်၍ အသုံးဝင်သည့် ယမနေစိုက်ခင်းများတည်ထောင်ရာတွင် မှန်ကန်သော မူရင်းဒေသ ရွေးချယ်နိုင်ရန်အလို့ငှာ ကွဲပြားသော မူရင်းဒေသများမှ ၄င်းသစ်မျိုး၏ ရှင်သန်မှုနှင့်ကြီးထွားမှုကို လေ့လာ နှိုင်းယှဉ်တင်ပြ ထားပါသည်။

Provenance Variation in *Gmelina arborea* Roxb.

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Abstract

Gmelina arborea is a fast growing species and is also a light demander like teak. Under favourable conditions it attains usable size and so requires only a short rotation for extraction. The species is either growing or planted since more than two decades in many countries viz. Brazil, India, Malaysia, Philippines, Thailand and some countries in Africa. This paper dealt with the performance of different Yemane provenances and height and survival of such tree are also presented.

Contents

1. Introduction and Literature Review

Forestland is disappearing at an ever-increasing rate due to population pressure. Wood consumption in the world market, however, is increasing with a rate of 1.9% annually and it is believed that in the near future, the world is likely to need about 4,000 million cubic meters of timber per year for all purposes. To meet the demand, there is no need to say that we could not totally depend upon the timber from natural forests and at the same time, we have to rely on plantations to meet the demand.

Up to the present, there have been 130 million hectares of plantation in the world and the area is, however, 3% of the world forest land, it can produce up to 800 million cubic meters of timber. In Myanmar, over 1.5 million acres of plantation have been established up to the year 1998. The major species are Teak (*Tectona grandis*), Pyinkado (*Xylia dolarbriformis*) and Padauk (*Pterocarpus macrocarpus*) because of the world timber market demand. However, in the recent year, there has been a slight change in timber market and has been trying to replace the species mentioned above with lesser-used species. Therefore, the focus on plantation species has been changing onto lesser-used species in many countries. There is no doubt that there are many useful timber species other than the species mentioned above. Among them, the most interesting tree species in the world is Yamene, *Gmelina arborea.* Because of the good quality of its wood and its rapid growth, the tree is well worth more attention for plantation purposes.

Gmelina arborea Roxb is a moderate -sized to large deciduous tree with opposite, broadly ovate acuminate, usually cordate leaves. The bark is light grey, smooth corky, and inner side is yellow and rapidly turning brown on exposure. Its wood is yellowish or greyish white, even grained, soft, light and strong. It can be seasoned well without warping and cracking and is very useful for carpentry of all kinds. The timber is suitable for indoor construction, paper pulping, veneer chipboard and particleboard (Labm, 1973).

Gmelina arborea Roxb occurs naturally in Parkistan, India, Srilanka, Myanmar, China, Laos, Cambodia and Vietnam (Lauridsen et. al 1987) and it is commoner in Myanmar than else where. It reaches its largest dimensions in the mixed deciduous forest but it is occasionally found in evergreen forests. Its choice of locality is wide but it shows a preference for moist fertile valleys and it does not thrive when the drainage is bad. In its natural habitat, the absolute maximum shade temperature varies from under 100 to 118 F, the absolute minimum 30 to over 60 F, normal rainfall is from 30 to 180 inch or more.

It belongs to the same family as teak (*Tectona grandis* Linn F), the Verbenaceae. Like teak, it is a light-demander, though it tolerates shade more than teak. It is also fast growing species and it has a very good coppicing power. Under favorable conditions, it attains a height of 100 ft. or more and a girth of 15 ft. From the beginning of 20th century, *Gmelina arborea* has been introduced in to many countries, and large plantations are found in South East Asia, West Africa and South America (Lauridsen, 86).

In Myanmar, large scale plantation of *Gmelina arborea* are not yet established and only it has been included in the trial plantations of commercial species in east Bago Yoma since 1980. According to the research conducted in that area, Gmelina stood first in order of preference for growth (Mehn Ko Ko Gyi et. al. 1985).

A spacing of not less than 10" x 10" and not more than 12" x 12" is suggested for Gmelina plantation (C Doo. 1986). Although being attacked by insect in the first and second year, Gmelina survived the attack and grows again very well after the attack (C Doo. 1986).

Because it has a habit of large crown, thinning should be done in the fourth or fifth year (F. D. instruction for thinning, 1939). But, no information of establishment of provenance trial is available at present and perhaps, this trial could be the first international provenance trial of Gmelina for Myanmar established in this country.

In this study, 8 provenances including 4 local provenances and 4 provenances outside the country were tested in three trial sites and the characters such as survival and height were compared. But, the characters such as diameter, wood density, stem straightness, health and axis characteristics were not included in the assessment. To cover the purpose of provenance testing from both genetic (variability) and utilization (wood products) point of view, the characters above mentioned need to be assessed. More research on provenance, therefore, is needed.

Prerequisites to establish a successful plantation of any species are proper site selection and planting best quality genetic material. Proper management is also required. If possible the species must be planted in its geographic range and planting materials (i.e., seed) of best quality and proven material should be used. Seeds from the selected mother tree are to be used at least, instead of using seeds haphazardly. The place, the provenance or the locality should be recorded for information.

The provenance trial is essential to tree improvement program and the provenance trial also serve as preservation plots for gene resources (Dr. Nyan Htun, 1992).

2. Materials

2.1. Number of provenance, seed sample

A description of provenances and experimental sites included in this program is provided by the Forest Management and Silvicultural Section, Forest Research Institute, Yezin. Table 1 below presents a summary.

Table 1. Number provenances and trials in the international provenance scheme of *Gmelina arborea*

Number of Provenances	Number of trials established	Number of trials assessed	Number of trials in evaluation
8	3	2	1

2.1.1. Provenance tested

There were 8 provenences represented in testing viz. 4 from Myanmar and 4 from South American countries such as Columbia and Costa Rica. No other detailed information about the seed sample that was sent form the University was available. Table 2 shows the detailed description of the selected provenances.

Table 2. Provenance description

Region	Collection Locality	Lat. (N)	Long. (E)	Elevation (m)	Rainfall (mm)
Myanmar I	Phetsut, Katha Township Northern Myanmar				1888
Myanmar II	Moeswe, Pyinmana township Eastern Aspect of Bago Yoma	19º 43'	96º 13'	95	1631
Myanmar III	Pawlangyi,Paukkaung Township, Western Aspect of Bago Yoma				
Myanmar IV	Kabaw, Oaktwin Township Eastern Aspect of Bago Yoma				
Columbia I	Not available	Na	Na	Na	Na
Columbia II	Not available	do	do	do	do
Columbia III	Not available	do	do	do	do
Costa Rica	Not available	do	do	do	do

Na = Not available

2.1.2 Sampling within provenances

In order to cover a sufficient amount of the genetic variation for provenance testing it is considered necessary to collect seed from minimum of 25 well dispersed trees in a population (Lauridsen. et.al.). But here, due to different circumstances, 20 trees were selected to collect seed in each local provenance. Table 3 shows the actual number of trees from which seed was collected and detailed information of seed collection operation made in Myanmar.

Table 3. Detailed description of number of seed trees and seed collection operation

Provenance	Date of seed collection	Number of seed trees	Implemented organization
Myanmar I	1-5-97 to 5-5-97	20	Forest Management and Silviculture section, F.R.I.
Myanmar II	24-4-97 to 8-5-97	20	Do
Myanmar III	11-5-97to22-5-97	20	Do
Myanmar IV	21-5-97to27-5-97	20	Do
Columbia I	Not available	Not available	Not available
Columbia II	Not available	Not available	Not available
Columbia III	Not available	Not available	Not available
Costa Rica	Not available	Not available	Not available

Seed sample were taken to seed laboratory, F. R. I. and germination percentage at arrival was recorded and raised in the nursery of forest management and silviculture section. Table 4 presents detailed information about seed obtained from different provenances.

Table 4. Detailed information about seed that was received in seed laboratory.

Seed source	Date of receipt	Germination percent at arrival	Germination percent at broadcasting	Date of broadcasting
Myanmar I	6-5-97	96%	51.5%	4-5-98
Myanmar II	9-5-97	87.5%	54.5%	Do
Myanmar III	27-5-97	95.5%	64.5%	Do
Myanmar IV	28-5-97	95%	58.25%	Do
Columbia I	9-4-98	75.5%	75.5%	10-4-98
Columbia II	Do	79.75%	79.75%	Do
Columbia III	Do	79.25%	79.25%	Do
Costa Rica	Do	71.25%	71.25%	Do

2.1.3 Trial site

Three *Gmelina* provenance trials were established in 1998 and all of the trials are situated on eastern aspect of Bago Yoma. Table 5 shows details about the trials established.

Table. 5 Details of the *Gmelina* provenance trials established in 1998.

Township	Site name	Latitude N	Longitude E	Mean temperature		Annual rainfall	Alt. (m)	R.H (%)
				Max	Min			
Pyinmana	Moeswe	19º56'35"	95º 55'48"	32.9	20.1	1426	108	75.9
Tatkon	Nanau	19º55'57"	96º 15'14"	33.0	21.0	1013	220	-
Yedashe	Ahmatgyikon	-	-	33.3	23.0	1245	-	52.23

3. Method

3.1. Experimental design

The experiment was laid out in Randomized plots replicated 4 times with 200 seedlings per replicate. In each replicate, there were 8 plots and the provenances were assigned at random to each plot and 25 trees (5 rows × 5 columns) with 9" × 9" spacing were planted there. Table 6 presents a brief information about the layout used for this experiment.

Table 6. A brief information of the layout

No. of Plots per Replicate	No.of Replicate	Total plots	No. of trees per plot	Total	
				Trees	Acres
8	4	32	25	800	1.5

According to the table mentioned above, each provenance occurs once and only once in each replicate and 200 seedlings of each provenance would be needed for the whole experiment.

A total of 800 potted seedlings were used. Brief information about the seedlings at planting time is shown in Table 7.

Table 7. Description of seedling at planting time

Seed source	Age (month)	Initial height (inch)
Local	2	10
Foreign	3	20

3.2 Planting and cultural operations

Planting was carried out from June to mid of July when there was regular rainfall. Cultural operations such as weeding, fire protections were done according to annual work plan for commercial plantations in Myanmar. Table 8 shows detailed information of operations.

Table. 8 Detailed information of operations.

Trial Site	Date of Planting	Cultural operations	
		Weeding	Fire protection
Moeswe, Pyinmana	26-6-98	✓	✓
Nanau, Tatkon	27-7-98	✓	✓
Ahmatgyikon,Yedashe	26-7-98	✓	✓

3.3 Assessment of Trials

Even though three trials were conducted, the trial plots established in Pyinmana Township was destroyed due to various causes and data collected from Tatkon trial site could not be used for further analysis because of too many plots were missing and those trials, therefore, were left out of assessment and evaluation. Just the trial plots in Yedashe Township could be put into assessment and final evaluation was carried out in year 2000.

3.4 Characters and Traits assessed

The parameters assessed here are height and survival. The methods and procedures were taken from "**Evaluation of a series of Teak and Gmelina provenance trials**" by Keiding.et.al.1978.

Characters assessed	Methods and procedures
Height	If more than one stem, measure height on the tallest stem.
Survival	Record the absence or presence of trees at each planting spot.

Observation on height and survival was carried out every 6 months. Table 9 shows a detailed description of trial assessment.

Table 9. Details description of trial assessment

Township	Site	Date of assessment	Items	
			survival	height
Yedashe	Ahmat-gyi-gon	31-7-98	✔	✔
		22-12-98	✔	✔
		16-6-99	✔	✔
		28-12-99	✔	✔
		21-6-2000	✔	✔
		23-12-2000	✔	✔

4. Results

4.1 Survival means

Table 10. GENSTAT output from analysis of variance of survival means in year 2000

Source of variation	Df	Sum of squares	Mean squares	v.r	F. pr
Repli	3	8612.0	2870.7	22.66	
Repli. Plot					
Prov	7	1520.0	217.1	1.71 ^{ns}	0.024
Residual	21	2660.0	126.7		
Total	31	12792.0			

ns = Not significant
CV = 14.5%

As shown in Table 10, it gives a variance ratio of 1.71for provenances. When this variance ratio is compared with tables of the F-distribution for 7 and 21 d.f, the variance ratio (1.71) is smaller than the tabulated F-value (2.49) at the 5% level of significance. Therefore, in terms of survival mean, it is clear that there is no significant difference among the provenances. But by DMRT, as indicated in table of treatment means for survival, there are significantly differences between some provenances at the 5 % level.

Table of treatment (T) Means dor Survival (%)
(Ave. Over 4 Reps)

Treatment	Ranks	Means
Columbia 1	5	75.000 b
Columbia 2	4	76.000 b
Columbia 3	1	95.000 a
Costa Rica	2	79.000 ab
Katha	3	78.000 ab
Moeswe	6	72.000 b
Polangyi	6	72.000 b
Ottwin	6	72.000 b
Mean		77.375

Means followed by a common letter are not significantly different at the 5% level by DMRT.

Provenance	Survival Mean	Rank
Columbia III	95	1
Katha	80	2
Costa Rica	79	3
Columbia II	76	4
Columbia I	75	5
Moeswe	72	6
Pawlangyi	72	6
Oaktwin	72	6

Hence, it should be stated that Columbia III is the best for survival at Yedashe trial site as shown in above ranking.

4.2 Mean height

Table 11. GENSTAT output from analysis of variance of mean height in year 2000

Source of variation	Df	Sum of squares	Mean squares	v.r	F. pr
Repli	3	655.59	218.53	3.37	
Repli. Plot					
Prov	7	485.72	69.39	1.07 ^{ns}	0.417
Residual	21	1363.66	64.94		
Total	31	2504.97			

ns = Not significant
CV = 24.4%

Similarly, in this ANOVA table, the variance ratio (1.07) for provenances is smaller than the tabulated F-value (2.49) at the 5% level of significance for 7 and 21 d.f. Hence, we accept that there is also no significant difference among the provenances in terms of mean height. By **Duncan's Multiple Range Test**, there is also no significant difference among provenance as shown in table of provenance means for height.

Table of Provenance Means for Height (inch), 2000
(Ave. Over 4 Reps)

Treatment	Ranks	Means
Columbia I	3	35 a
Columbia II	1	39 a
Columbia III	2	38 a
Costa Rica	4	33 a
Katha	6	30 a
Moeswe	8	28 a
Pawlangyi	7	29 a
Oaktwin	5	31 a
Meam		33

Means followed by a common letter are not significantly different at the 5 % level by DMRT.

Although there is no significant difference, Columbia II is superior than other provenances in Yedashe trial site as indicated in the following ranking.

Provenance	**Mean Height (inch)**	**Rank**
Columbia II	39	1
Columbia III	38	2
Columbia I	35	3
Costa Rica	33	4
Oaktwin	31	5
Katha	30	6
Pawlangyi	29	7
Moeswe	28	8

5 Discussion

In Myanmar, Yemane, *Gmelina arborea* has not been grown in a large scale plantations as yet, but it has been growing in small scale plantations for over 50 years.

For a successful plantation, there is a great need of using the best quality genetic material. Research activities are also important. Seed exchange between Forest Research Institute and North Carolina State University has been started since 1997 and the provenance trial was established in 1998.

Yemane, it does not, however, thrive well where the drainage is bad, unfortunately, almost all the sites selected were in bad drainage area. Especially in Yedashe trial site, the selected site was waterlogged area with stiff clay loam. Hence, although it says that the growth is fast, it was found that there was an average height of 3' at the age of 3 years.

Cultural operations were carried out properly and so were the assessment operations timely. Data collected from this trial were analyzed with software named DATA PLUS and GENSTAT.

As there are many countries where this species is included in plantations, there should be further observations on provenance variation in its some characters such as height, diameters, tree forms and wood density etc.

In any cases, the results obtained from the trial on provenance variation in *Gmelina arborea* would be useful for plantation establishment program to some extent in the future.

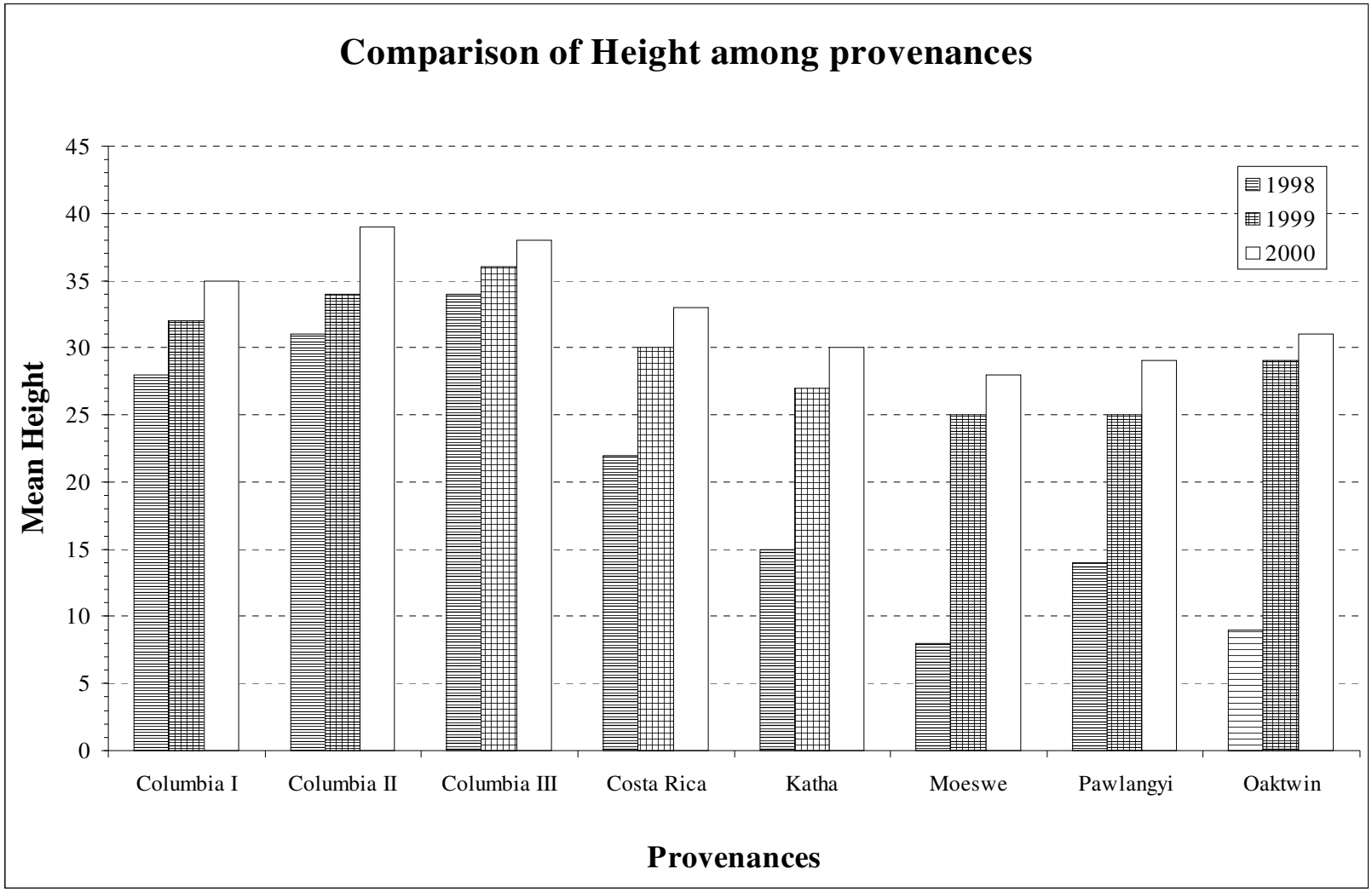
6. Conclusion

(1) According to statistical analysis, there were no significant differences between provenances for mean height but there were significant differences in term of survival means between some provenances.

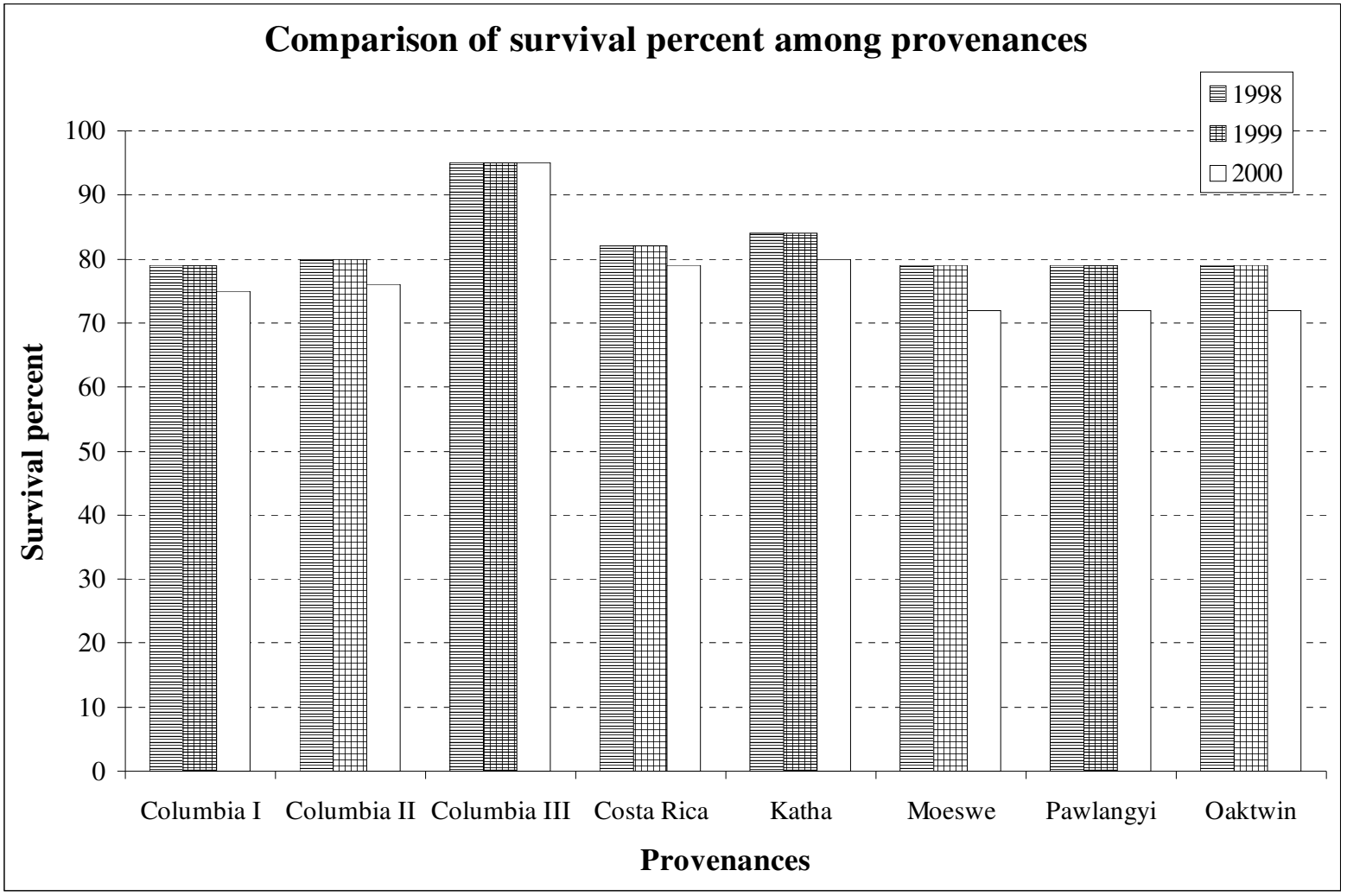
(2) According to statistical analysis, Columbia III is superior than other provenances followed by Katha, Costa Rica, Columbia II, Columbia I, Moeswe, Pawlangyi and Oaktwin for survival mean. Columbia II is superior than other provenances followed by Columbia III, I, Costa Rica, Oaktwin, Katha, Pawlangyi and Moeswe in term of mean height at Yedashe trial site.

(3) Further study is needed to conduct the same trial under different locations.

Appendix 1


Comparison of Height among provenances
Mean Height
45
40
35
30
25
20
15
10
5
0
1998
1999
2000
Columbia I
Columbia II
Columbia III
Costa Rica
Katha
Moeswe
Pawlangyi
Oaktwin
Provenances

Appendix 2


Comparison of survival percent among provenances
1998
1999
2000
100
90
80
70
60
50
40
30
20
10
0
Survival percent
Columbia I
Columbia II
Columbia III
Costa Rica
Katha
Moeswe
Pawlangyi
Oaktwin
Provenances

Appendix 3

Plot means of *Gmelina arborea* provenance trial

Location Ahmat-gyi-gon Research Station Year of assessment. 2000
Yedashe Township

No.	Provenance	Block I		Block II		Block III		Block IV		Total average	
		Sur %	A.H	Sur %	A H	Sur %	A.H	Sur %	A.H	Sur %	A.H
1	Columbia I	88	30	100	37	44	34	68	38	75	35
2	Columbia II	92	34	96	40	56	38	60	44	76	39
3	Columbia III	100	40	100	36	96	39	84	39	95	38
4	Costa Rica	84	34	100	41	60	29	72	30	79	33
5	Katha	88	32	100	34	48	24	84	30	80	30
6	Moeswe	96	50	88	27	60	20	44	16	72	28
7	Pawlangyi	96	39	88	32	48	19	56	25	72	29
8	Oaktwin	88	51	100	40	60	15	40	20	72	31

Sur % = Survival percent
A.H = Average Height in inch

GENSTAT output from analysis of variance of survival means in 2000

Source of variation	Df	Sum of squares	Mean square	V.r	F.pr
Repli	3	8612.0	2870.7	22.66	6
Repli.plot					
Prov	7	1520.0	217.1	1.71 ^{ns}	0.160
Residual	21	2660.0	126.7		
Total	31	12792.0			

ns = not significant
CV = 14.5

GENSTAT output from analysis of variance of mean height in 2000

Source of variation	Df	Sum of squares	Mean square	V.r	F.pr
Repli	3	655.59	218.53	3.37	
Repli.plot					
Provenance	7	485.72	69.39	1.07 ^{ns}	0.417
Residual	21	1363.66	64.94		
Total	31	2504.97			

ns = not significant
CV = 24.4

Appendix 4

Plot means of *Gmelina arborea* provenance trial

Location Ahmatgyigon Research Station Year of assessment. 1999
Yedashe Township

No.	Provenance	Block I		Block II		Block III		Block IV		Total average	
		Sur %	A.H	Sur %	A H	Sur %	A.H	Sur %	A.H	Sur %	A.H
1	Columbia I	92	29	100	33	52	33	72	34	79	32
2	Columbia II	100	33	100	35	56	33	64	37	80	34
3	Columbia III	100	39	100	36	96	34	84	34	95	36
4	Costa Rica	88	32	100	39	64	26	76	25	82	30
5	Katha	92	31	100	31	52	21	92	26	84	27
6	Moeswe	96	49	96	27	60	14	64	12	79	25
7	Pawlangyi	96	37	92	29	60	15	68	20	79	25
8	Oattwin	100	50	100	37	64	13	52	15	79	29

Sur %= Survival percent
A.H = Average Height

GENSTAT output from analysis of variance of survival means in 1999

Source of variation	Df	Sum of squares	Mean square	V.r	F.pr
Repli	3	7405.50	2468.50	27.95	
Repli.plot					
Prov	7	851.50	121.364	1.38 ^{ns}	0.266
Residual	21	1854.50	88.31		
Total	31	10111.50			

ns = not significant
CV = 11.44

Appendix 5

GENSTAT output from analysis of variance of mean height in 1999

Source of variation	Df	Sum of squares	Mean square	V.r	F.pr
Repli	3	1037.34	345.78	5.55	
Repli.plot					
Prov	7	442.22	63.17	1.01 ^{ns}	0.450
Residual	21	1309.41	62.35		
Total	31	2788.97			

ns = not significant
CV = 26.3

Plot means of *Gmelina arborea* provenance trial

Location Ahmatgyigon Research Station Year of assessment. 1998
Yedashe Township

No.	Provenance	Block I		Block II		Block III		Block IV		Total average	
		Sur %	A.H	Sur %	A H	Sur %	A.H	Sur %	A.H	Sur %	A.H
1	Columbia I	96	28	100	28	92	27	100	28	79	28
2	Columbia II	100	30	100	27	96	31	100	36	80	31
3	Columbia III	100	35	100	35	96	33	100	34	95	34
4	Costa Rica	92	21	100	20	92	22	100	24	82	22
5	Katha	96	16	100	16	100	14	100	15	84	15
6	Moeswe	100	7	100	8	96	8	92	8	79	8
7	Pawlangyi	100	15	96	15	84	14	96	14	79	14
8	Oattwin	100	9	100	9	96	9	92	10	79	9

Sur %= Survival percent
A.H = Average Height

GENSTAT output from analysis of variance of survival means in 1998

Source of variation	Df	Sum of squares	Mean square	V.r	F.pr
Repli	3	130	43.33	3.70	
Repli.plot					
Prov	7	86	12.27	1.05 ^{ns}	0.429
Residual	21	246	11.71		
Total	31	462			

ns = not significant
CV = 3.51

Appendix 6

GENSTAT output from analysis of variance of mean height in 1998

Source of variation	Df	Sum of squares	Mean square	V.r	F.pr
Repli	3	10.125		0.57	
Repli.plot					
Prov	7	2745.375	392.196	65.69 **	< 0.001
Residual	21	125.375	5.970		
Total	31	2880.375			

* * = Highly significant
CV = 12.10

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