Rapid characterization of genetically improved loblolly pine families using acoustic technique

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Abstract

Tree improvement is one of the important components of forestry and forest products industry development. Advances in tree improvement have reduced the rotation period drastically from over 30 years to 25 years or less. This reduced rotation period has presented wood quality issues in recent years. Hence, there is the need to assess the wood quality properties of the existing elite progenies using non destructive method. The objective of this study was to use acoustic technique to characterize 14 year old genetically improved loblolly pine families into stiffness and velocity classes. The results indicate significant site and family effect on the diameter of the selected families. However, modulus of elasticity (stiffness) is significantly influenced by genetic family. Again, there is no significant difference between the static stiffness of the small clear samples and the dynamic stiffness estimated for their respective trees. It can be inferred from the above results that, the diameter growth of loblolly pine is both site and family dependent while stiffness is only family dependent. Also, the acoustic technique can be used to screen the trees into the expected stiffness of the products.

Introduction

- Loblolly pine is one of the most important tree species in the southeastern USA contributing substantially to the economy
- In order to increase return on investment from the loblolly pine plantations, tree improvement programs over the years focused mainly on developing elite progenies with high tolerant to diseases and pest, high girth and height growth rates. These elite progenies have been deployed for plantation development.
- Advances in tree improvement have reduced the rotation period drastically from over 30 years to 25 years or less. This reduced rotation period has presented wood quality issues in recent years. However, most of the internal properties of wood controlling quality such as density, velocity, and modulus of elasticity have been found to be highly heritable than morphological properties such as tree diameter and height. This means that wood quality parameters can be incorporated into tree improvement programs.
- The objective of this study was to use acoustic technique to characterize 14 year old genetically improved loblolly pine families into stiffness and velocity classes. This is to ensure the improvement of elite families with superior morphological and quality properties.

Materials and Methods

- Genetically improved loblolly pine plantations were established at Yulee, FL and Waycross, GA in the year 2000. Each plot was divided into 15 blocks and one seedling per family was planted on each block. Each block contained all the families. The same loblolly pine families and planting design were used for both plots.
- Fifteen families were selected for this study in Spring 2014 when the trees were 14 years (Fig A). All the 15 trees per each family were tested using Director ST 300 acoustic tool (Fig B) and diameter at breast height measured.
- One tree per each family was selected, harvested and bucked into 2.0 m logs. The logs were processed into 2.5x2.5x41cm small clear samples to determine the static modulus of elasticity following the ASTM D143 (2007) . The three point static bending test was performed using Zwick Roell testing machine (Fig. C)
- Moisture content and basic density of the test samples were also determined.
- Modulus of elasticity of the trees was estimated using equation ρV^2 where ρ is the basic density and V is acoustic velocity.

Results

The Tables and Figures presents some of the results obtained

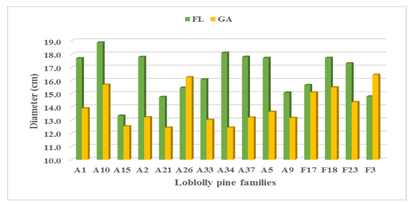

Figure 1: Diameter of standing trees on Florida and Georgia sites

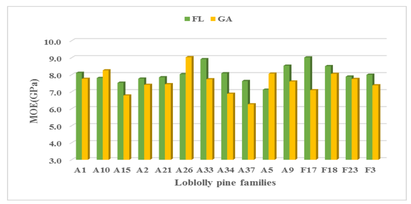

Figure 2: Predicted modulus of elasticity of standing trees on Florida and Georgia sites

Figure 3: Predicted MOE of standing tree and Actual MOE of small clear samples for Georgia site

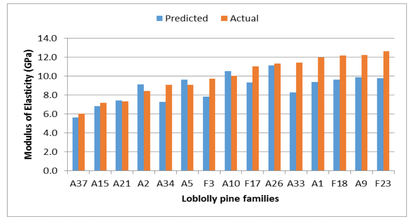

Figure 4: Predicted MOE of standing tree and Actual MOE of small clear samples for Georgia site

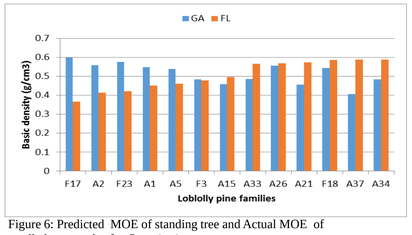

Figure 6: Predicted MOE of standing tree and Actual MOE of small clear samples for Georgia site

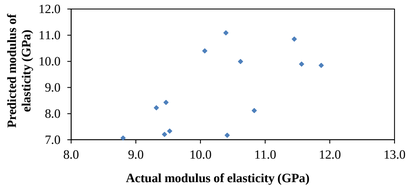

Figure 8: Relationship between the Actual MOE of small clear samples and Predicted MOE of standing tree for Florida site

Table 1: ANOVA of the diameter of loblolly pine families for Florida and Georgia sites

Source	DF	Sum Squares	Mean Square	F Value	Pr > F
Site	**1**	**418.93**	**418.92**	**40.79**	**<.0001**
Block	14	237.48	16.96	1.65	0.07
Family	**14**	**317.46**	**22.67**	**2.21**	**0.01**
Site*Family	14	252.67	18.04	1.76	0.05
Family*Block	191	1785.61	9.348	0.91	0.72
Site*Block	14	150.09	10.72	1.04	0.41

Table 2: ANOVA of the predicted modulus of elasticity of loblolly pine families for Florida and Georgia sites

Source	DF	Sum Square	Mean Square	F Value	Pr > F
Site	1	0.115	0.115	0.03	0.86
Block	14	54.23	3.873	0.99	0.47
Family	**14**	**243.96**	**17.43**	**4.44**	**<.0001**
site*Family	**14**	**489.49**	**34.96**	**8.91**	**<.0001**
Family*Block	192	787.04	4.10	1.04	0.39
Site*Block	14	68.04	4.86	1.24	0.25

Table 3: ANOVA of velocity of loblolly pine families for Florida and Georgia sites

Source	DF	Sum Square	Mean Square	F Value	Pr > F
Site	**1**	**1.10**	**1.10**	**5.52**	**0.02**
Block	14	3.25	0.23	1.16	0.31
Family	14	4.49	0.32	1.61	0.08
Site*Family	14	4.18	0.30	1.50	0.12
Family*Block	191	41.47	0.22	1.08	0.31
Site*Block	14	3.28	0.23	1.17	0.30

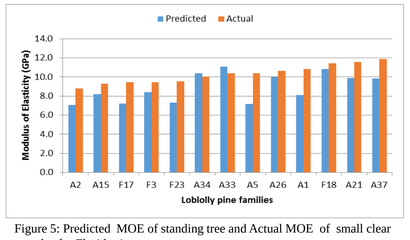

Figure 5: Predicted MOE of standing tree and Actual MOE of small clear samples for Florida site

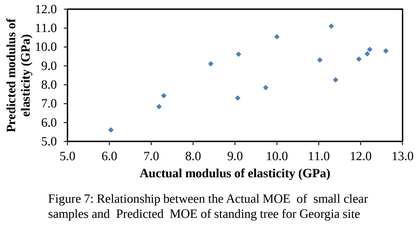

Figure 7: Relationship between the Actual MOE of small clear samples and Predicted MOE of standing tree for Georgia site

Table 4: Statistics of fitted model to estimated the expected MSR grade boards from standing tree predicted modulus of elasticity.

Site	a	b	SE	R^2	Adj R^2	P-val
FL actual MoE	-1.37	0.99	1.21	0.41	0.36	0.018
GA actual MoE	3.31	0.56	1.03	0.57	0.53	0.001
All	2.60	0.62	1.13	0.46	0.44	<.000

Actual MoE = a + b*predicted standing tree MoE
a is the intercept and b is the slope

Discussions

- Generally, there are significant site and family effects on diameter growth (Table 1, Fig 1) indicating that the selected pine families will exhibit different growth rates on different site.
- There is a significant family effect on modulus of elasticity of the selected families (Fig2, Table 2) indicating some of the pine families have higher modulus of elasticity irrespective of the site. This supports the hypothesis that modulus of elasticity is hereditary.
- There is no significant differences between the predicted modulus of elasticity of the standing trees and the small clear samples obtained from them. This means that the acoustics technique can be used to characterize the pine families into their expected modulus of elasticity classes

Conclusions

- The results confirmed trees can be improved for superior modulus of elasticity since site do not significantly affect this quality property in the present study
- A significant site effect on diameter but non significant site effect on modulus of elasticity makes selecting families with higher diameter growth for plantation development an advantage for presently studied pine families
- The acoustic techniques can be used to screen the pine families in their expected modulus of elasticity categories

References

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