Genetic variation for Wood Basic Density, Knot index and Their Relationships with Growth Traits of *Acacia auriculiformis* in Northern *Vietnam*

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Introduction

- *A. aur* introduced into Vietnam in the 1960s
- An important tree species (southern parts of Vietnam)
- *A. aur* suitable for timber and pulp production
- 90,000 ha of *A. aur, and* planted for sawn timber and pulpwood.
- However, the productivity of *A. aur* plantations is poor
- The breeding goal is to combine rapid stem volume growth with high quality stems and desired wood properties to produce well adapted trees of good quality for lumber and pulp wood

Introduction (cont.)

- Currently, the information on genetic parameters & GxE for *A. aur* is limited
- Developing a breeding program for *A.aur* requires estimation of the information in order to determine the best strategy for breeding

Objectives of the study

- To determine the genetic control of growth traits, wood basic density, bark thickness, straightness and branch characteristics
- To examine the genetic relationships between these traits and growth traits
- To test the effectiveness of pilodyn penetration as an indirect measure of wood basic density
- The implications of these results for the development of a breeding program of *A. aur* in northern Vietnam are considered.

Material and methods

- Material
  - 140 families from 13 provenances of *A. aur* in a thinned progeny test (9 year old)
  - provenances from PNG, Queensland and SSO families (known better provenances)
  - row-column design with 8 replicates, four-tree row plots
  - Two phenotypic thinning made in the test at the age of 3 and 5 years, retain best tree per plot
- Location of trial
  - Ba Vi (Northern Vietnam)

Material and methods (cont.)

- Measurements

  HT, DBH, FOR (5 scores), STR (5 scores), PIN, BRK and branch characteristics (BDIA, BLEN, BNUM) were recorded at age 3, 5, 9 years for the 4400, 1091 & 775 trees

- Calculations
  - Tree volume calculated from ht and dbh (previous work)
  - Knot Index
  - Wood density (6 mm cores, 3 sections per core)

Statistical analysis

- The linear mixed model (individual tree)

$$\mathbf{y} = \mathbf{X}_B\mathbf{m} + \mathbf{X}_P\mathbf{p} + \mathbf{Z_W}\mathbf{w} + \mathbf{Z_N}\mathbf{n} + \mathbf{Z_T}\mathbf{t} + \mathbf{Z_F}\mathbf{f} + \mathbf{e}$$

- ASREML

Results

Provenance differences

- Provenance diffs modest but note these are selected better provenances
- Coen River, Sakaerat, Morehead River best
- The lowest density was found in Wenlock River provenance (0.55), but its knot index was the best in the test (0.71).

CSIRO Nº	HT	DBH	STR	VOL	FOK	BRK	PIN	KI	DEN
17961	12.4	14.4	1.8	49.7	3.0	6.0	6.9	1.26	0.57
17966	12.0	14.4	2.1	48.8	3.0	6.3	6.7	1.22	0.56
18854	11.7	14.3	2.3	47.0	3.0	5.8	7.0	0.90	0.58
18998	12.0	14.1	2.0	48.1	3.0	4.8	8.9	1.14	0.56
19244	12.2	14.4	1.9	51.9	2.8	5.1	8.5	0.94	0.56
19245	11.7	13.9	1.9	45.9	2.5	4.7	8.5	0.90	0.58
19246	11.2	13.6	1.8	44.9	2.6	4.9	8.2	1.14	0.57
19249	11.7	13.6	1.7	46.8	3.0	4.9	8.3	0.71	0.55
19250	**13.1**	**14.9**	**1.9**	**60.6**	**3.2**	**5.6**	**7.9**	**1.16**	**0.58**
19251	12.3	14.9	2.1	56.3	3.6	4.9	8.3	1.02	0.59
19254	12.3	14.6	1.7	52.6	2.9	5.4	7.7	1.03	0.56
19255	11.5	14.4	1.7	47.9	2.7	5.6	7.8	0.76	0.58
19326	12.4	15.3	1.8	58.0	2.8	5.8	7.8	0.87	0.59
F- test	n.s	**	n.s.	**	n.s.	**	***	**	*

Heritability and Coefficient of variation

1. σ^2_A was different from zero for all studied traits at age 9 (p<0.05)
2. h^2 for growth traits & STR increased over time from age 3 to ages 5 and 9
3. h^2 for growth traits, DEN & PIN were high
4. h^2 for stem quality traits were lower than for basic density (0.12 to 0.39)
5. h^2 increased from inner wood to outer wood
6. CV_A for DEN stabilized around 8% at different ages
7. Selective thinning affected genetic parameter estimates

Trait	Unit	family mean	σ^2_A	h^2	SE of h^2	CV_A
HT3	m	7.38	0.120	0.13	0.07	4.5
HT5	m	9.84	0.280	0.14	0.06	5.4
HT9	m	12.19	1.860	0.36	0.10	11.2
DBH3	cm	7.93	0.280	0.17	0.06	6.7
DBH5	cm	11.06	0.570	0.24	0.07	6.8
DBH9	cm	14.83	1.080	0.36	0.09	7.0
VOL3	dm^3/tree	9.53	2.810	0.18	0.06	17.6
VOL5	dm^3/tree	24.1	22.500	0.24	0.07	19.7
VOL9	dm^3/tree	53.93	192.500	0.39	0.09	25.7
STR5	score	2.55	0.170	0.20	0.07	16.2
STR9	score	1.86	0.240	0.27	0.10	26.2
DEN	g/cm^3	0.58	0.002	0.61	0.12	8.3
DEN_1	g/cm^3	0.53	0.002	0.40	0.10	8.6
DEN_2	g/cm^3	0.58	0.002	0.55	0.11	8.3
DEN_3	g/cm^3	0.63	0.003	0.55	0.12	9.0
BRK	mm	5.63	0.800	0.39	0.10	15.9
PIN	mm	7.73	1.300	0.47	0.11	14.7
FOK	score	2.9	0.360	0.31	0.10	20.7
KI	mm^2/mm^2	0.93	0.040	0.12	0.01	21.4

Age-age genetic correlations

- High genetic age-age correlations for growth traits and STR between ages 3-5; 5-9
- High genetic correlations, close to unity, for wood density between segment 1, 2 & 3

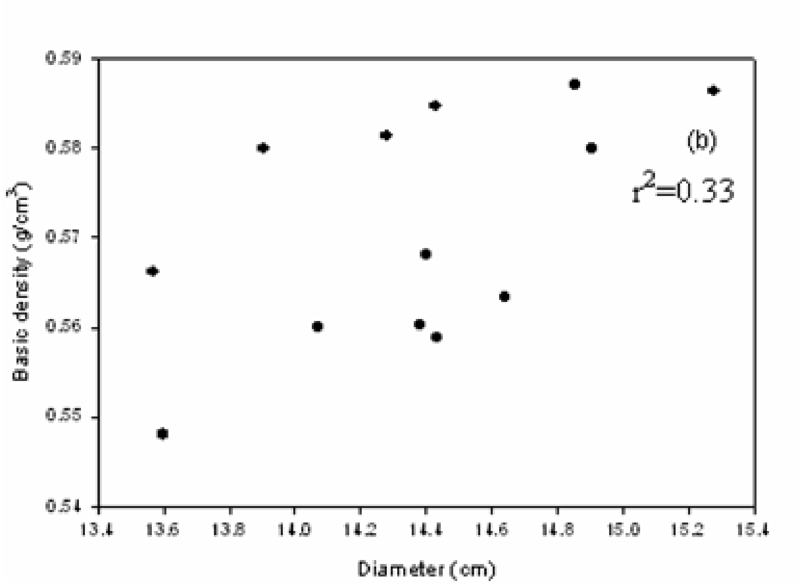
Trait	r_A	r_P
HT3-HT5	0.91±0.13	0.66±0.02
HT3 HT9	0.64±0.17	0.53±0.03
HT5-HT9	0.91±0.08	0.83±0.01
DBH3-DBH5	0.99±0.12	0.72±0.02
DBH3-DBH9	0.86±0.10	0.53±0.03
DBH5-DBH9	0.93±0.05	0.76±0.01
STR5-STR9	0.87±0.18	0.27±0.03
VOL5-VOL9	0.91±0.05	0.80±0.01
DEN_1-DEN_2	0.97±0.05	0.66±0.02
DEN1-DEN3	1.02±0.03	0.80±0.01
DEN2-DEN3	0.99±0.02	0.91±0.01

Trait-trait correlations

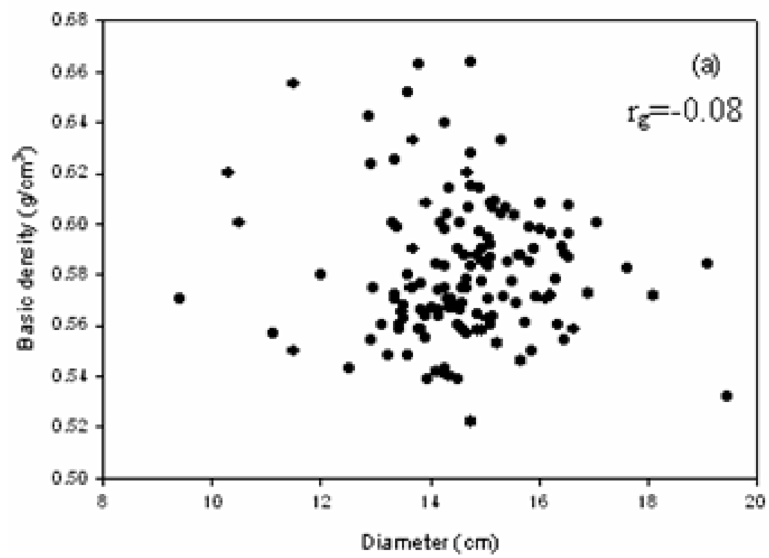
Trait	HT	DBH	DEN	PIN	STR	FOK	BRK	KI
HT		0.79±0.09	-0.07±0.18	-0.07±0.18	0.79±0.15	0.33±0.19	0.59±0.15	-0.45±0.28
DBH	0.70±0.02		-0.08±0.19	-0.06±0.18	0.96±0.13	0.37±0.20	0.65±0.13	-0.11±0.30
DEN	-0.06±0.02	-0.07±0.04		-0.88±0.05				
PIN	0.02±0.04	0.005±0.04	-0.08±0.04					
STR	0.40±0.03	0.43±0.03				0.30±0.22	0.50±0.20	0.47±0.35
FORK	0.24±0.03	0.19±0.04			0.32±0.03		0.16±0.21	-0.05±0.34
BRK	0.33±0.03	0.50±0.03			0.15±0.04	0.09±0.04		-0.24±0.31
KI	-0.21±0.04	-0.14±0.04			-0.02±0.04	-0.16±0.04	-0.02±0.04	

1. The correlations among the growth traits were strong
2. Negative correlations between DEN, PIN, FOK, KI and the growth traits were low
3. High negative correlation between DEN and PIN (-0.88)
4. STR correlated strongly with the growth traits, but moderately with BRK
5. The correlations among the stem and branch quality traits were weak, (-0.28 to 0.5)

Trait-trait genetic correlations (cont.)



Provenance level



Family level

Response Selection Efficiency

Trait	r_A	r_P	tj	tm	RSE
HT3-HT5	0.91±0.13	0.66±0.02	3	5	1.46
HT3 HT9	0.64±0.17	0.53±0.03	3	9	1.16
HT5-HT9	0.91±0.08	0.83±0.01	5	9	1.01
DBH3-DBH5	0.99±0.12	0.72±0.02	3	5	1.39
DBH3-DBH9	0.86±0.10	0.53±0.03	3	9	1.79
DBH5-DBH9	0.93±0.05	0.76±0.01	5	9	1.31
STR5-STR9	0.87±0.18	0.27±0.03	5	9	1.37
VOL5-VOL9	0.91±0.05	0.80±0.01	5	9	1.27
DEN_1-DEN_2	0.97±0.05	0.66±0.02	3	5	1.38
DEN1-DEN3	1.02±0.03	0.80±0.01	3	9	2.61
DEN2-DEN3	0.99±0.02	0.91±0.01	5	9	1.78

1. Forward selection for the growth traits and wood density was shown to give a higher genetic gain per time unit at approximate age 3, 5 than at age 9 and age 5 than at age 9
2. These results indicate that the optimum age of selection is at an early age

Conclusion

1. Significant differences between provenances and families for most studied traits
2. High heritabilities and age-age correlations for growth traits.
3. Wood density was under strong genetic control, either based on direct measurement of increment cores or indirect measurement of pilodyn penetration, with these traits being highly correlated.
4. Straightness, bark thickness and forking also had high heritabilities, while knot index had low heritability.
5. High age-age correlations for wood density and straightness
6. Genetic correlations between forking, bark thickness, knot index and growth traits were weak and unfavorable with large standard errors.
7. It should be possible to use a selection strategy that combines both good quality traits and good growth of *A. aur* in a breeding program for northern Vietnam.

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