WOOD GENETIC VARIATION OF *Acacia auriculiformis* AT WONOGIRI TRIAL IN INDONESIA

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ABSTRACT

Provenance/progeny trial of *Acacia auriculiformis* plants growing at Wonogiri, Indonesia comprised of 129 half-sib families obtained from 12 provenances. The study used 3 year-old plants, beginning from seedling. Parameters included growth traits (diameter, height, stem form and bark thickness), and wood characteristics (color, moisture content, and specific gravity). Genetic variations in the traits were studied and genetic parameters were estimated.

High variation among the *A. auriculiformis* families within provenance in the trial were found on diameter, height, stem form, wood color (percentage of black color area), and moisture content. Individual heritabilities in *A. auriculiformis* plant were 0.33 for height, 0.40 for diameter, 0.54 for stem form, 0.48 for wood color, 0.46 for moisture content, and 0.18 for both bark thickness and wood specific gravity. Diameter, stem form and wood color indicated substantial improvement on the traits and wood characteristics that would follow selection for this trait.

Keywords: Genetic variation, growth, stem form, wood characteristic.

I. INTRODUCTION

Acacia auriculiformis is a multi-purpose species widely used in Asia Africa and South America. It grows normal even in poor or less fertile soil. The wood can be used for fuel wood, windbreak, erosion control, construction and a street tree (Gunn and Midgley, 1991). Recently, wood portion of this species was used in Java Island, Indonesia as fuel wood and furniture. Therefore, it is important to improve its growth, thereby producing good seed quality.

Most of the tree improvement programs for many years included growth, form, adaptability, and pest resistance in their assessments but did not include wood properties as such (Zobel and Jett, 1995). Now, breeding program of *Acacia auriculiformis* in Indonesia will include wood properties as traits for

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selection. Furthermore, study on wood variation in the trial site, is important to conduct.

As an interest to develop this species, Institute for Biotechnology and Forest Tree Improvement Research, Yogyakarta-Indonesia and JICA have established a progeny trial seedling orchard of *A. auriculiformis* at Wonogiri. This paper reported a study of genetic variation on growth, stem form, and wood characteristic together with genetic correlation between traits on the seedling seed orchard at 36 months after planting.

II. MATERIALS AND METHODS

A. Field Trials

The seedling orchard trial of *A. auriculiformis* was established at Wonogiri; Central Java; Indonesia at approximately 7°80' South latitude and 110°93' East longitude with elevation of about 141 m above sea level. Annual rainfall was 1878 mm with a 7-8 months of dry season. The mean minimum temperature of the coolest month was 25°C , while the mean maximum temperature of the hottest month was 33°C.

Seed orchard planting was arranged in row arrays within rows, the spacing of the planted seed was 2 m, while the distance between rows was 4 m. This trial comprised of orchard seeds of 131 family (half-sib) which come from 12 provenances. Information about the family origin of the seeds and other related details are presented in Table 1. The design of seedling orchard trial was arranged in a randomized complete block with nested pattern and using five replications. The number of planted tree seed per plot was four for each replication.

Table 1. Family origin of *A. auriculiformis* seed and other related information

Tentative Code	CSIRO No.	Provenance	Latitude (S)	Longitude (E)	Altitude (m)	No. of Families
1	17553 & 17554	Bensbach, PNG	8° 53'	141°17'	25	34
2	18359	Lower Poscoe River, QLD	12°34'	143° 1'	20	15
3	17961	Olive River, QLD	12° 11'	142° 59'	4	10
4	18247 & 17941	Wenlock River, QLD	12° 28'	142° 4'	60	27
5	17966	Boggy Creek, QLD	15° 52'	144° 53'	240	10
6	16756	E Normamby River, QLD	15° 5'	145° 5'	160	2
7	17941	Kennedy River, QLD	15° 26'	144° 1'	100	5
8	18601	R Orchard Melville Int.. QLD	11° 34'	130° 34'	20	12
9	17704	Wenlock R. & Tribs., QLD	12° 47'	142° 49'	70	2
10	16608	Bandabern of Bulla, WP-PNG	8° 58'	141°19'	20	2
11	16606 & 18246	Morehead R, WP-PNG	8° 43'	141° 36'	18	11
12	16609	Belamuk, WP-PNG	8° 54'	141°16'	15	1
		Total of families				131

B. Assessment

Assessment of the traits was conducted on 2 grown trees per plot (tree proposed for thinning) in three replications in the seedling seed orchard of 3 years old. The traits were tree diameter, stem form and wood characteristic. Diameter was measured at 100 cm above the ground and stem-form (straightness) was measured using score of one for the worst to five for the best. Wood characteristics i.e. bark thickness, moisture content, percentage of black color area on the`wood, and specific gravity were assessed using stem disk wood samples materials obtained at 100 cm above the ground and the standard method on wood technology have been applied to measured the traits.

C. Statistical Analysis

1. Analyses of variance

The individual trait related data were analyzed using the ANOVA procedure in Genstat Version 5.3.2 to check for homogeneity of variances (Payne *et al*., 1987).

Analyses on the data were based on the following linear model that as described before corresponded to a randomized block design with a nested pattern as follows:

$$Y_{ijkl} = \mu + R_i + P_j + F_k(P_j) + e_{ijk}$$

where:

μ : represents the overall mean;

R_i : represents the effect of the i^{th} replicate

P : represents the effect of the j^{th} provenance group

$F_k(P_j)$: represents the effect of the k^{th} family which is nested within the j^{kth} provenance group

e_{ijk} : represents the residual error with a mean of zero.

Y_{ijk} : is the plot mean of the k^{th} family within the j^{th} provenance group in the i^{th} replicate

2. Genetic parameters

Appropriate variance components for genetic parameter computation were obtained by mixed model analyses. Replicates and provenance groups were regarded as fixed effects while families-within-provenance groups were judged as random effects (Williams and Matheson, 1994) These analyses were conducted using the REML procedure in GENSTAT 5.3.2.

The mean family-within-provenance group variance components were used to estimate mean within provenance group covering individual tree heritabilities (denoted as h_i^2) separately for each trait as follows:

$$h_i^2 = 1/r * s_f^2 / s_p^2$$

where:

r : coefficient of relationship

s_f^2 : variance between families-within-provenance groups

s_p^2 : phenotypic variance

: $(s_f^2+s_m^2+s_t^2)$

s_m^2 : variance between plots

s_t^2 : variance between trees within plots (Williams and Matheson, 1994)

The coefficient of relationship used in computation of the individual tree heritabilities was assumed to be 0.3 rather than the value of 0.25 used for half-sib families. This was based on the assumption that, *Acacia* sp. as being open–pollinated families from natural *A. auriculiformis* stands carry a degree of inbreeding resulting from selfing and neighborhood inbreeding.

Genetic correlations (denoted as r_g) were calculated according to the methodologies described by Williams and Matheson (1994) based on the following formula:

$$r_g = \frac{Cov_f(X,Y)}{[\sigma_f^2 (x) . \sigma_f^2 (y)]^{1/2}}$$

where,

$Cov_f(X,Y)$ = covariance of the two traits at the family level, σ_f^2 (x) = family- level variance components of trait (x) σ_f^2 (y) = family- level variance components of trait (y).

III. RESULTS AND DISCUSSION

The data means as estimated by the REML procedure that covered height (m), diameter at100 cm, stem-form, bark thickness, percentage of black color (%), moisture content (%), and specific gravity are given in Table 2. There was significant variation in most traits between provenance groups and between families-within-provenance groups (Table 3).

Table 2 shows that the best performances of height and diameter are with Wenlock R & Tribs, QLD provenance. Bandabern of Bulla. Meanwhile, WP-PNG provenance has highest percentage of black color area. Further, the lowest moisture content was found in E Normamby River, QLD provenance. Meanwhile Kennedy River, QLD provenance affords the highest ranking of specific gravity in the trial. Generally, the mean of stem-form of all provenances revealed the low score, and this is because the wood samples were collected by removing tree (with bad performance) within plot selection.

Table 2. Mean of growth traits (height, diameter, stem form, bark thickness) and wood characteristics (percentage of black color area, moisture content, specific grafity) of 3 years old *A. auriculiformis* trees grown from their seeds on the progeny test of seedling seed orchard situated at 12 provenances in Wonogiri

No.	Provenances	Height (m)	Diameter (cm)	Stem-form	Bark thick-ness (mm)	Percent-age of black color area (%)	Mois-ture Content (%)	Specific gravity
1	Bensbach, PNG	9.800	10.873	1.264	3.329	12.697	60.343	0.568
2	Lower Poscoe River, QLD	9.983	11.263	1.549	3.526	15.007	67.221	0.542
3	Olive River, QLD	9.973	11.626	1.632	3.643	22.558	68.148	0.556
4	Wenlock River, QLD	10.015	11.045	1.442	3.383	18.436	66.921	0.569
5	Boggy Creek, QLD	9.527	9.955	1.426	3.512	16.744	62.958	0.567
6	E Normamby River, QLD	8.750	11.333	1.667	3.077	19.027	55.540	0.533
7	Kennedy River, QLD	9.916	10.854	1.462	3.318	15.737	59.818	0.585
8	R Orchard Mel-ville Int.. QLD	9.992	11.465	1.214	3.462	11.368	67.756	0.552
9	Wenlock R. & Tribs., QLD	10.233	12.450	1.333	3.920	13.639	64.467	0.584
10	Bandabern of Bulla, WP-PNG	8.700	9.300	1.167	2.397	20.287	66.990	0.497
11	Morehead R, WP-PNG	9.767	11.344	1.362	3.640	14.801	63.794	0.550
12	Belamuk, WP-PNG	10.850	11.175	1.000	3.320	16.505	63.917	0.540

Table 3. Analysis of variance on the growth trait and wood characteristics of 3 years old of *A. auriculiformis*

Items	Source of variation	d.f	Mean of square
Growth trait			
1. Height	Provenance	11	4.119 ***
	Family within provenance	113	1.268 **
	Residual	412	0.862
2. Diameter	Provenance	11	12.448***
	Family within provenance	115	7.707 ***
	Residual	437	4.788
3. Stem-form	Provenance	11	0.833 ***
	Family within provenance	115	0.663 ***
	Residual	422	0.361
4. Bark thickness	Provenance	11	2.333 *
	Family within provenance	115	1.531
	Residual	437	1.228
Wood characteristics			
1. Percentage of black color area	Provenance	11	320.276 ***
	Family within provenance	115	152.999 ***
	Residual	437	
2. Moisture content	Provenance	11	480.774
	Family within provenance	115	544.576 ***
	Residual	435	
3. Specific gravity	Provenance	11	0.0098 ***
	Family within provenance	115	0.0030
	Residual	437	0.0024

Note: *** = Significant at $P < 0.001$, ** = Significant at $0.01 < P < 0.001$, * = Significant at $0.05 \leq P < 0.01$

Table 3 shows that differences in height, diameter, stem-form, and percentage of black color area were highly significant both between provenance groups and between family-within-provenance groups. Meanwhile, differences in moisture content were highly significant between families-within-provenance groups but not significant between provenance. However, bark thickness and specific gravity varied significantly between provenance groups, and they both did not vary significantly between families-within-provenance.

Estimation of individual heritability, phenotypic correlation, and genetic correlation between the traits in the seedling seed orchards progeny trial of *A. auriculiformis* at Wonogiri-Indonesia are presented in Table 4. No traits were as expected, strongly associated with the traits and wood characteristics. However, individual heritability for height, diameter, stem-form, percentage of black color area and moisture content.

The progeny trial seedling seed orchard of *A. auriculiformis* at Wonogiri, Indonesia revealed great genetic variation on percentage of black color area, moisture content, stem-form and growth trait. According to some reports, the genetic differentiation between populations was high in *A. auriculiformis*. Wickneswari and Norwati (1993) have studied seeds that covered 18 populations of *A. auriculiformis* obtained from natural reverine and coastal forests in Australia and Papua New Guinea and they reported that genetic differentiation between populations was high, indicating that 73 % of isoenzyme variation was revealed among progenies within populations. Aini *et al.* (1994) also reported the provenances differed very significantly ($p < 0.001$) in their growth performance at provenance trial of 12 months old of *A. auriculiformis* growing on Peninsular Malaysia.

Table 4. Estimation of individual heritability (h^2_i), phenotypic correlation (r_p) and genetic correlation (r_g) between growth traits and wood characteristics

Trait	h^2_i	Phenotypic correlation and genetic correlation					
		Diameter	Stem-form	Bark thickness	Perc. of black color area	Moisture content	Specific gravity
Growth traits							
Height	0,33	r_p = 0,26 r_g = 0,21	r_p = 0,06 r_g = 0,13	r_p = 0,07 r_g = -0,12	r_p = 0,10 r_g = -0,01	r_p = - 0,11 r_g = -0,31	r_p = 0,09 r_g = -0,40
Diameter	0,40		r_p = -0,05 r_g = 0,01	r_p = 0,51 r_g = 0,50	r_p = 0,45 r_g = 0,35	r_p = 0,23 r_g = 0,39	r_p = 0,16 r_g = -0,18
Stem-form	0,54			r_p = -0,02 r_g = -0,001	r_p = -0,03 r_g =-0,13	r_p = -0,11 r_g = -0,08	r_p = -0,12 r_g = -0,48
Bark thickness	0,18				r_p = 0,23 r_g = 0,46	r_p = 0,15 r_g =0,29	r_p = 0,21 r_g = -0,53
Wood characteristics							
Perc. of black color area	0,48					r_p = 0,26 r_g = 0,31	r_p = 0,23 r_g = 0,40
Moisture content	0,46						r_p = -0,21 r_g = -0,25
Specific gravity	0,18						

Relationship between height and diameter in the progeny test seedling seed orchard of *A. auriculiformis* was weak with respect to both genetic and phenotypic correlation. In this case, measurement of height and diameter were assessed on the trees having bad growth performance (height, diameter, and stem-form) in plot in the seedling seed orchard. The worst trees in plot were removed and wood samples collected when trees selection within plot were carried out.

The percentage of black color area, moisture content, stem-form and growth trait are very appropriate to include in the selection program on the progeny trial seedling seed orchard of *A. auriculiformis*. The estimates of genetic and phenotypic correlations was apparently advantageous on correlations between the traits (growth traits, form, moisture content and percentage of black color area). Also, the estimates of individual heritability for the traits were high. However, negative genetic correlations were found between growth and wood characteristic. These indicate they are not possible to simultaneously achieve major gains in growth traits and wood traits.

The wood specific gravity and bark thickness are not necessary to include in the breeding program, because families differences are not significant on the two traits and the estimate of individual heritability of the traits appeared to be low. It indicates that the traits are not strong under genetic control in *A. auriculiformis*. The low heritability for wood density (specific gravity) also was experienced by Rone in *Picca abies* on 1970 (Zobel and Jett, 1995). They both listed in table of narrow sense heritability values for wood density in the hard pine, but the table showed that most of heritability for wood density in the some species were high.

IV. CONCLUSIONS AND RECOMENDATION

Wood characteristics and growth variation between family in seedling orchard trial of *A. auriculiformis* are important for updating breeding strategy in the species. Genetic correlation among wood characteristics and growth in progeny test seedling seed orchards of *A. mangium* are needed to conduct tree selection in the seedling seed orchard to obtain high genetic gain for wood and growth.

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