Preliminary Observation of Flowering Strength in Seedling Seed Orchard of *Acacia mangium* in Wonogiri, Central Java

Hiroo YAMADA[1], Rina Laksmi HENDRATI[2], Parlindungan TAMBUNAN[2] and Hisao KAWASAKI[3]

Summary : Flowering strength in seedling seed orchard of *Acacia mangium* was observed in relation to family variation and provenance variation. The flowering strength was assigned visually to one of the flowering categories: 0-none ; 1-light ; 2-medium ; 3-heavy. The flowering strength was significantly different among families and provenances. The repeatability of flowering strength was estimated to be 0.256. Theflowering strength of lower part of tree crown was lower than that of upper part of the tree crown. Theeffects of stand density and tree size of the seedling seed orchard on flowering strength were examined.

1 Introduction

Genetic improvements of fast growing tree species of Acacias have been intensively conducted in Indonesia. The species of Acacias have been extensively planted for pulp and paper production in Sumatra and Kalimantan islands under the program, Indonesia Forestry Action Program by Ministry of Forestry in Indonesia, of the industrial plantation since the late 1980s. To secure this program, it is required to produce improved seeds from seedling seed orchards (Kurinobu, 1997).

Establishment of seedling seed orchard has three purposes. It is used for the progeny test at the beginning, then it will be used for seed production after roguing. Finally, it will be used for the base populations to select plus trees in the next generation. To attain the purpose of seed production in the seedling seed orchard, it is important not only to estimate the amount of seed production but also to examine the individual and family variation in seed production. It is likely that a lot of seeds will be produced from a few families when the individual and family variation is large in seed production.

Tree improvement strategy using seedling seed orchard includes thinning operations (Kurinobu, 1997). The thinning is performed in the following three steps; 1) first thinning is to cull poorer trees in each plot, 2) second thinning is to leave best trees per plot, 3) final thinning is to leave better families in the seedling seed orchard. Thus the thinning will leave the best trees from the better families. Analysis of the factors affecting the seed production, either individual or family variation, will also be needed.

It is commonly observed that species cultivated outside of their natural distribution may have variable flowering and fruiting phenologies (Sedgley et al, 1991). Many observations showed that this variation could be caused by climatic condition, site or genetics (Griffin and Sedgley, 1989). Peak

(1) Forest Tree Breeding Center
3809-1 Ishi, Juo, Taga, Ibaraki 319-1301 Japan
林木育種センター

(2) Forest Tree Improvement Research and Development Institute
インドネシア林木育種研究所

(3) The Forest Tree Improvement Project (Phase2) in The Republic of Indonesia
Ftirdi, JL.Palagan Tentara Pelajar Km.15 Purwobinagun, Pakem, Sleman,
Yogyakarta, Indonesia
インドネシア林木育種計画 フェーズII

fruiting of this species was in May in Sabah, Malaysia (James Josue, 1991), in June-July in Sepilok and Tawau, eastern parts of Sabah, Malaysia (Sedgley et al, 1991) and in September in Peninsular Malaysia (Ibrahim and Awang, 1991).

Flowering and fruiting of this species had been intensively studied in Malaysia and Australia. One tree of *Acacia mangium* bore spikes ranging between 32,000-133,000 (Sedgley et al, 1991). The number of flowers per spike ranged from 105 to 392 (Ibrahim and Awang, 1991, Sedgley et al, 1991). Percentage of the spikes setting pods was 21.1%, while number of mature pods per spike ranged 1.8-2.8, and number of seeds per pod was 5.5 (Sedgley et al, 1991). Each kilogram of *Acacia mangium* seeds has 76,000 seeds in PNG, 98,000 seeds in Queensland, 123,000 seeds in Sabah, 99,000-102,000 seeds in South Sumatra and 160,000 seeds in West Java (Iriantono, 1998).

This paper presents the results of preliminary observation of flowering of *Acacia mangium* growing in the trial of seedling seed orchards in Central Java.

2 Materials and methods

2.1 Gneral information of the study site

The trial of seed source (seedling seed orchard; SSO) of *A. mangium* was established in Wonogiri, Central Java. Details of the trial site and experimental design are shown in Table 1. This SSO was established in January 1995 with seeds of 134 families from 14 provenances (Table 2) in PNG and Australia (Figure 1). In July 1997, first thinning of 50% in each plot to cull poorer trees was conducted.

2.2 Investigation methods

The flowering strength of individual trees (1,004 individuals of 134 families) was observed in the whole blocks at 3.5 years after planting, in July 1998. Arrangement map of measured trees is shown in Figure 2. One best tree, which was vigorous, good form of trunk, and good growth, in each family plot was selected as a sample tree. The flowering status of the upper, middle, and lower parts of the crown of each sample tree was evaluated using the flowering categories: 0 none, 1 light, 2 medium, and 3 heavy. Mean of these values determined for the three parts of the crown was defined as a flowering strength of the sample tree. The results were then analyzed using one-way

Table 1. General information of Wonogiri SSO

Species	*Acacia mangium*
Seed sowing date	3, October, 1994
Planting date	14-16, January, 1995
Spacing	4m x 2m
Latitude	7.32, South
Longitude	110.41, East
Altitude	141m
Climate type	A
Precipitation	1878mm/year
Max. Temperature	38.23℃
Min. Temperature	21.21℃
Slope	10%
Site Area	3.53ha
Design	Split-plot
Number of trees/plot	4
Number of families	134
Number of replication	7

Table 2. Provenances of seeds used for the SSO

Provenance	Country	Latitude	Longitude	Altitude (m)
1	PNG	-8.05	142.22	50
2	PNG	-8.08	141.87	30
3	PNG	-8.07	141.90	25
4	PNG	-8.07	142.05	40
5	PNG	-8.07	141.92	25
6	PNG	-8.02	142.97	12
7	PNG	-8.08	142.87	45
8	AUSTRALIA	-12.73	143.27	40
9	AUSTRALIA	-12.75	143.28	37
10	AUSTRALIA	-12.73	143.27	30
11	AUSTRALIA	-12.73	143.27	20
12	AUSTRALIA	-12.57	143.20	25
13	AUSTRALIA	-12.82	143.28	10
14	AUSTRALIA	-12.82	143.27	40

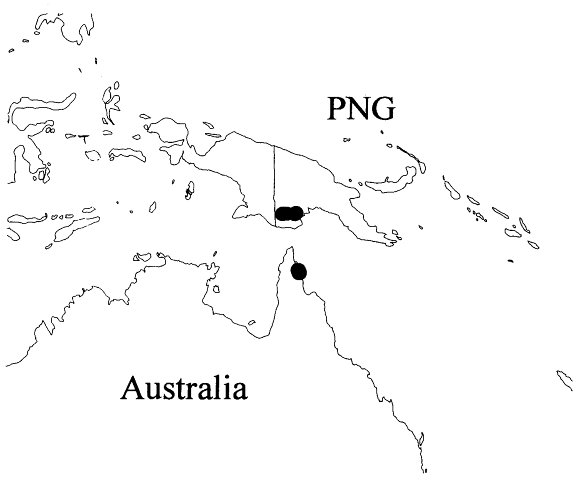

Figure 1. Provenance of seeds used for the SSO

ANOVA.

Actual number of spikes was observed in Wonogiri SSO to confirm the accuracy of the survey of flowering strength mentioned above. Ten representative trees of each flowering category 1, 2 and 3 were selected as the sample trees for counting the number of spikes. The total number of branches (N) and DBH were recorded for each of those trees. Three representative branches were sampled from the three part of the tree crown. All the spikes on each branch were counted, and mean number of spikes per branch was estimated (X). Total number of spikes per tree was defined as $N \times X$.

3 Results and discussion

3.1 Relationship between flowering strength and number of flowering spikes

The relationship between flowering strength and number of spikes of individual tree is shown in Figure 3. The number of flowering spikes (y) was approximated by an exponential function of the flowering strength (x), that is;

$$y = 1000e^{0.752x} \qquad r^2 = 0.304 \quad P < 0.001$$

$$= 2121.2\ (2.12)^{x-1} \cdots\cdots \ (1) \qquad e = 2.7183$$

The equation (1) shows that the number of flowering spikes of an individual is about 2,100 at

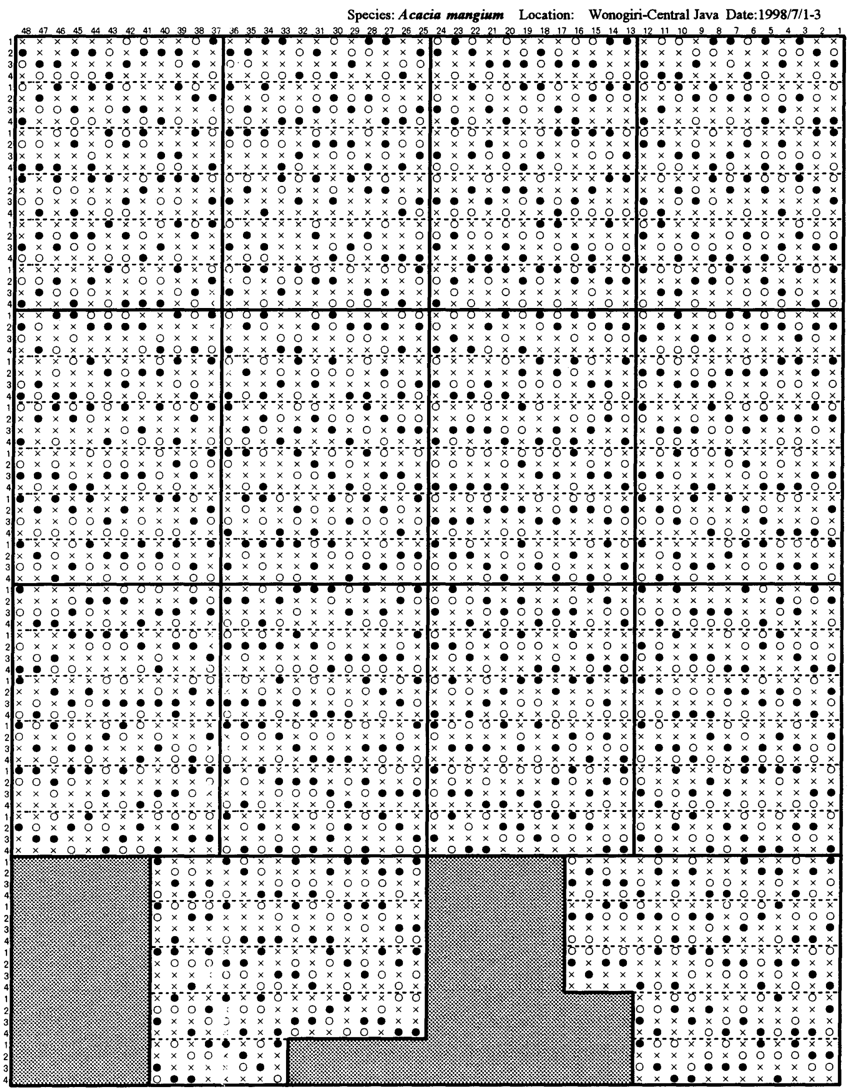

Figure 2. Map of trees in the SSO in Wonogiri. Each plot has four trees of the same family. ●: measured tree, ○: left tree after thining, ×: cut tree by thining, respectively.

flowering category 1. The number of spikes is increased by 2.12 times, when the flowering category increases from 1 to 2.

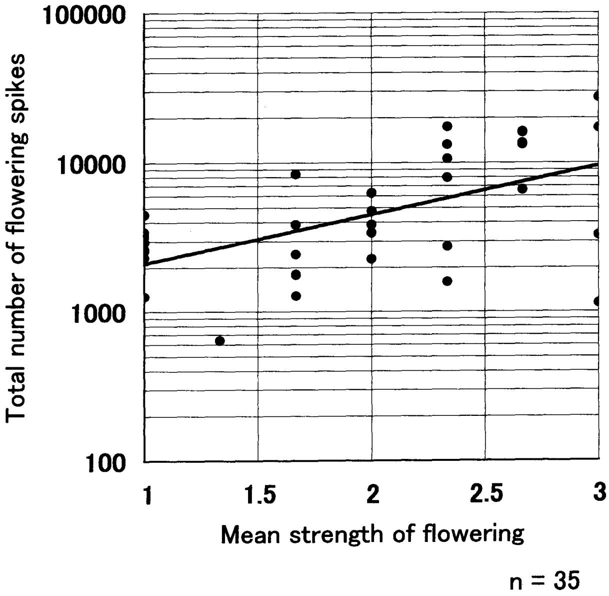

Figure 3. Relationship between flowering strength and number of spikes.

3.2 Family variation in flowering strength

The mean flowering strength of family ranged from 0.24 to 1.76 (Figure 4). The mean flowering strength was significantly different among families (Table3, $P < 0.001$: one-way ANOVA). The repeatability of flowering strength was estimated to be 0.256.

3.3 Vertical variation in flowering strength

Vertical variation in flowering strength on each layer of crown parts, upper, middle, and lower parts, is shown in Figure 5. The flowering strength of upper, middle, and lower part was 1.19, 1.33, and 0.36, respectively. The flowering strength was significantly different among three crown parts (Table 4, $P < 0.001$: one-way ANOVA). The L.S.D. value was 0.11 at 0.1% significance level. The light condition may be principal factor of the flowering strength.

3.4 Density effect of flowering strength

The relationship between stand density and flowering strength was examined. Density index was defined as the number of neighbor trees within the range from 2m to 4m distances from the sample tree. The density index ranged from 0 to 8.

Frequency distributions of the density index classified into four categories according to the flowering strength are shown in Figure 6. The mean density index was 3.81 for the trees of category 1 (flowering strength (x) = 0), 3.68 for those of category 2 ($0 < x \leqq 1$), 3.44 for those of category 3 ($1 < x \leqq 2$), 3.08 for those of category 4 ($2 < x \leqq 3$), respectively. Density index was significantly different among categories of flowering strength (Table 5, $P < 0.001$: one-way ANOVA). The differences among mean density indexes of each category were larger than the value of L.S.D. at 5% significance level except for the difference between those of categories 1 and 2. Trees of heavy flowering

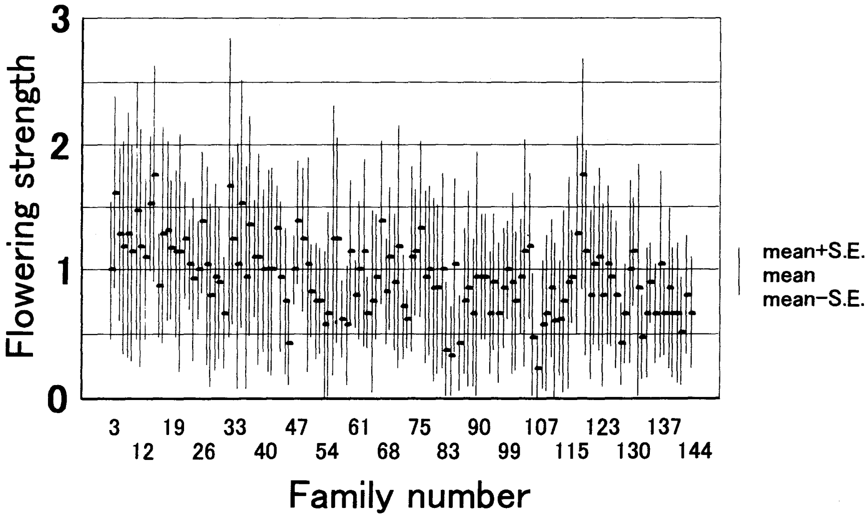

Figure 4. Family variation in flowering strength.

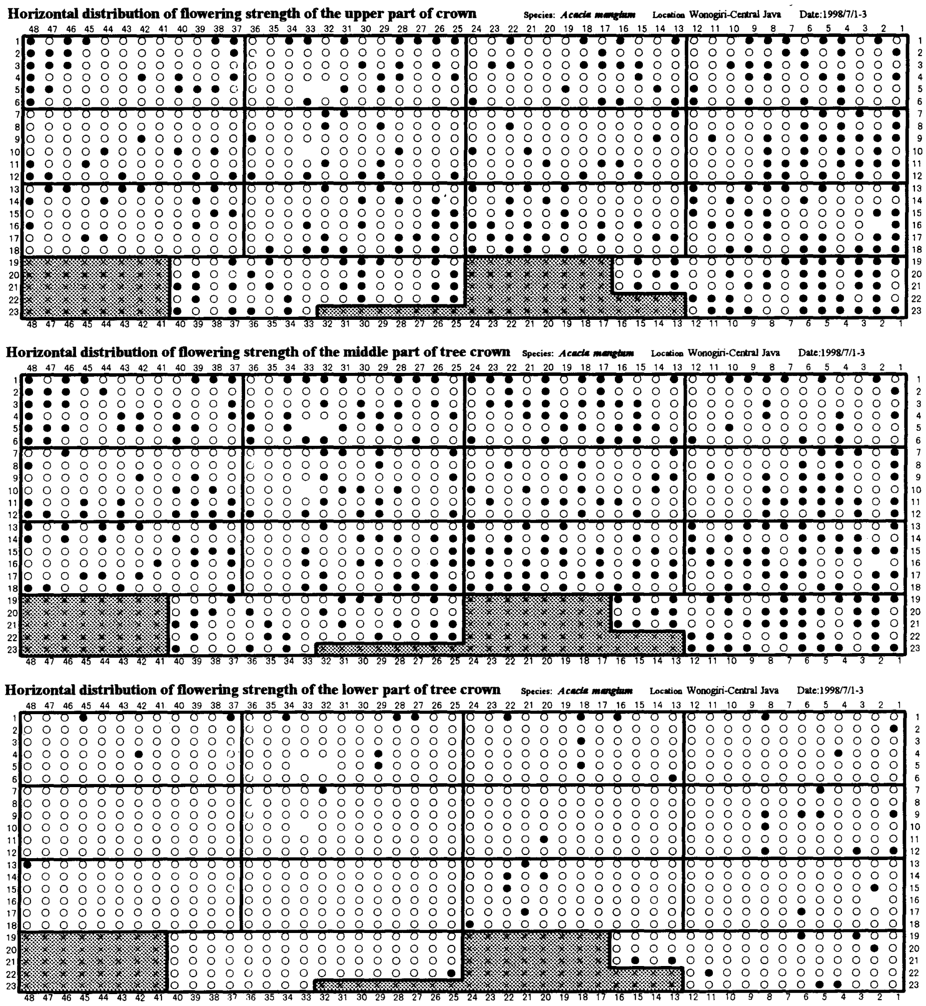

Figure 5. Horizontal distribution of flowering strengh each part of tree crown.
●: flowering strength is 2 and 3, ○: flowering strength is 0 and 1, respectively.

Table 3. ANOVA for flowering strength on family

Factor	S.S.	df	M.S.	F-value
Family	81.94	133	0.62	1.5***
Error	356.49	870	0.41	
Total	438.44	1003		

***: significant at 0.1% level

Table 4. ANOVA for flowering strength on crown part

Factor	S.S.	df	M.S.	F-value
Crown part	561.96	2	280.98	479.8***
Error	1769.12	3021	0.59	
Total	2331.08	3023		

***: significant at 0.1% level

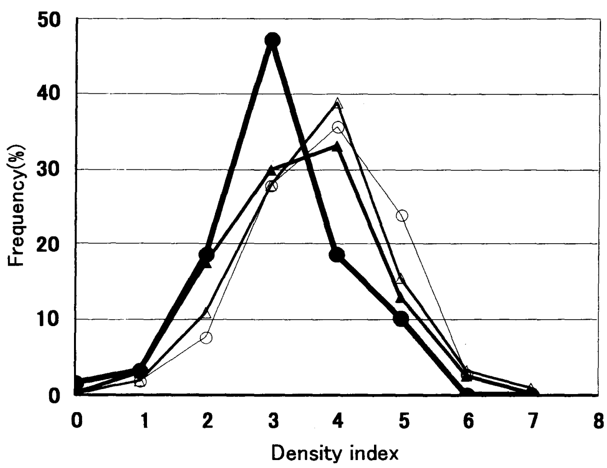

Figure 6. Frequency distributions of density index.
○: flowering strength=0, 0<△≦1,
1<▲≦2, 2≦●3, respectively.

Table 5. ANOVA for density index on flowering strength

Factor	S.S.	df	M.S.	F-value
Category	30.98	3	10.33	8.4***
Error	1217.64	995	1.22	
Total	1248.62	998		

***: significant at 0.1% level

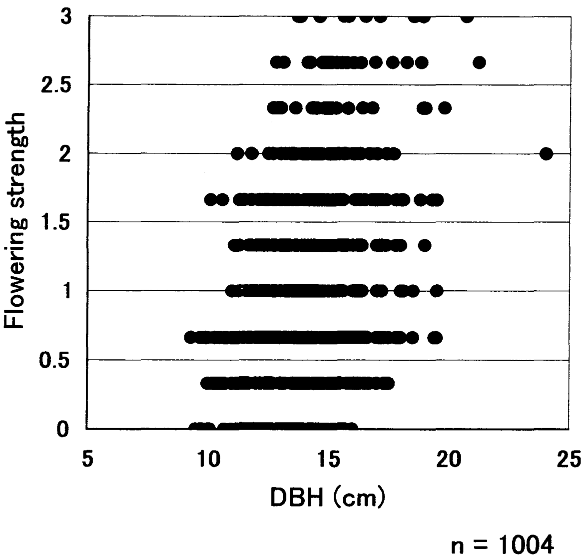

Figure 7. Relationship between DBH and flowering strength.

strength tended to have lower density index, and situated on the open distribution of trees. Tree density and／or light condition might affect the flowering strength. Further analysis on the relationship between adjacent trees and flowering strength should be made. The planting distances and the branch spread in the SSO should also be examined in relation to the flowering strength.

3.5 Growth status and flowering strength

The relationship between DBH and flowering strength was examined. Positive correlation was observed between DBH and flowering strength (Figure 7, $r^2=0.101$: $P<0.001$). The range of DBH was narrow on Figure 7. Further analysis of the interrelation between tree growth and flowering strength should be made.

3.6 Geographical variation in flowering strength

All families planted in this SSO are classified

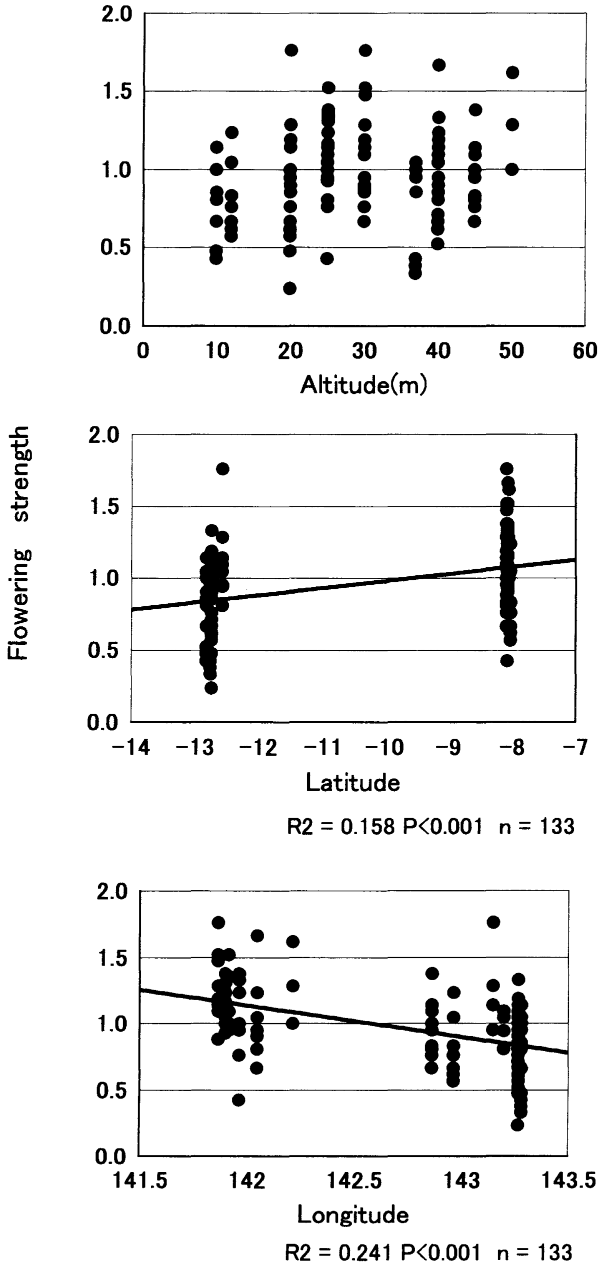

Figure 8. Relatioship of flowering strength with altitude, latitude, and longitude ot the provenance.

Table 6. AVOVA for flowering strength on provennance

Factor	S.S.	df	M.S.	F-value
Provenance	3.55	13	0.27	4.2***
Error	7.69	119	0.06	
Total	11.24	132		

***: significant at 0.1% level

into 14 provenances of their seed sources. The relationships of flowering strength to longitude, latitude and altitude of the provenances are shown in Figure 8. Flowering strength was not significantly correlated with altitude, but was significantly correlated to longitude and latitude ($P<0.001$). The flowering strength is significantly different among provenances of seed sources (Table 6, $P<0.001$: one-way ANOVA).

The provenances of PNG showed higher flowering strength in comparison with the provenances from Australia. There is a possibility that the flowering time of provenances in PNG is earlier than that of provenances in Australia. Synchronous flowering of all trees in SSO will enhance the productivity and the quality of seeds. In contrast, differences in flowering time may cause the decrease in seed production and the genetic diversity. Frequent observations during the flowering season are needed to understand the dynamics of flowering throughout all families.

The seed production is likely to be plastically determined according to the internal and environmental conditions. It is well known that the tree age, weather, light condition, pollination and damage by disease and insect pest affect the seed production. There are the good crop years and poor crop years. Moreover, flowering or fruiting of tropical fast-growth species, e.g. Acacias and Eucalyptus, will be influenced by season, which is not always clear in Indonesia. The seed production will be better understood by the continuous observation of the flowering or fruiting strength and by the investigation of the influence of the internal and environment conditions.

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ジャワ島中部ウオノギリに設定されたアカシアマンギューム実生採種園における着花性について（予報）

山田浩雄[1]・Rina Laksmi HENDRATI[2]・Parlindungan TAMBUNAN[2]・河崎久男[3]

要旨：アカシアマンギューム実生採種園における着花性の家系間差と産地間差を調査した。着花性は目視によって４段階の着花指数（０～３）を与えて評価した。着花指数は家系と産地によって有意に異なっていた。着花指数の反復率は0.256と推定された。樹冠下部の着花指数は樹冠上部に比べて低かった。実生採種園の林分密度と個体サイズが着花指数に及ぼす影響について検討した。

(1)　林木育種センター
(2)　インドネシア林木育種研究所
(3)　インドネシア林木育種計画　フェーズII