# PROVENANCE BY SITE IINTERACTION OF *QUERCUS ACUTISSIMA* IN KOREA

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*Quercus acutissima* is a native tree species in eastern Asia, in China, Korea and Japan. In Korea, it is a major hardwood tree species in temperate regions and naturally distributed from Hamgyung-do (39°50`) in North Korea to Jeju province (33°20`) in South Korea. Its vertical range is 10~1,100m above sea level. The timber of *Quercus acutissima* has been used for structure wood, tool handle, mine timber, furniture, charcoal and culture medium for mushroom (Cho 1989). Because of its high wood desirability and economic value, the timber consumption and utilization are expected to continue and even increase in the future. Breeding program of *Quercus acutissima* was started with the selection of 207 plus-tree from natural stands in 1990's. Since 1992, total 13.6ha of seedling seed orchards were established. However, the amount of seed production from the seed orchards are not enough to provide seed demand for reforestation due to the differences of flowering and pollination time among individuals in the seed orchards. Thus, large amounts of seeds for reforestation are still supplied from seed production plantations at each province. However, the geographic variation and the growth characteristics of the provenances of *Q. acutissima* are not fully understood. This study was conducted to investigate provenance by site interaction of *Q. acutissima*.

## Materials and Methods

To examine provenance by site interaction and stability of *Q. acutissima* provenances, data were collected from three provenance trials established by Korea Forest Research Institute in 1996 with 17 provenances (Tables 1 and 2). The seed sources were systematically selected to cover whole geographic range of *Q. acutissima*. The field trials were established with a randomized complete block design with 3 replications. Each provenance was planted in 10-tree row plot in each block and at a spacing of 1.8m x 1.8m. The data of survival rate and height growth were obtained from measurement at age 12. Data set was analyzed with a linear regression model (Finlay and Wilkinson 1963) to evaluate adaptability and stability of *Q. acutissima* provenances at different environments. The linear regression model is:

$$Y_{ij} = \mu + g_i + E_j + b_i E_j + \bar{e}_{ijk}$$

where $Y_{ij}$ = mean of the *i*th variety in the *j*th environment; $\mu$ = general mean; $g_i$ = mean of *i*th variety over all environment; $E_j$ = environmental index for *j*th environment ($Y_{.j} - Y_{..}$); b = regression coefficient; and $\bar{e}_{ijk}$ = residual variation which is assumed to be zero for the values averaged over replications.

## Results and Discussion

According to linear regression model, provenance by site interaction effect was significant for height growth ($p<0.001$). The interaction term explained 7.2% of total variation. Most variation was attributed to environment effect (89.3%). Among the variance of GxE interaction, 15.9% was explained by regression analysis which was based on regression of provenance performance on environment index. The residual GxE interaction was attributed to random deviations. Most of provenances were significantly different from the unity (b=1.0). Adaptability of provenances to test sites were estimated with mean height growth and regression slope (Table 3). Hwasoon, Yeongam and Yeongi provenances are sensitive to environmental change and well adapted to preferable environment. Gangwha, Heungseong, Whaseong, Namyang, Keumreung, Cheongyang and Wonju are less sensitive to environmental change. Particularly, Keumreung showed higher adaptability to poor environment. According to these results, it is suggested that an appropriate provenance to planting site is required for *Q. acutissima.* However, early growth assessments may not be reliable for assessing GxE at mature ages in forest trees (Gwaze et al. 2001; Yeiser et al. 2001). Therefore, long term monitoring of growth performance is required, until mature age. In addition, studies on the relationship between adaptive traits and environments are required to delineate seed zone and achieve advanced breeding for *Q. acutissima*.

Table 1. The location of 17 provenances of *Quercus acutissima*.

| Provenances | Latitude(N) | Longitude(E) | Altitude(m) |
|---|---|---|---|
| Gangwha | 37°38' | 126°28' | 15 |
| Heongseong | 37°27' | 127°59' | 218 |
| Wonju | 37°26' | 128°00' | 280 |
| Hwaseong | 37°12' | 126°59' | 50 |
| Namyang | 37°11' | 126°48' | 60 |
| Joongwon | 37°04' | 127°57' | 140 |
| Eumseong | 36°52' | 127°39' | 180 |
| Geosan | 36°50' | 127°53' | 155 |
| Yeongi | 36°31' | 127°16' | 38 |
| Cheongyang | 36°26' | 126°54' | 415 |
| Buyeo | 36°21' | 126°46' | 500 |
| Okcheon | 36°19' | 127°36' | 83 |

| | | | |
|---|---|---|---|
| Keumreung | 36°14' | 128°26' | 190 |
| Chilgok | 36°04' | 128°36' | 350 |
| Hwasoon | 35°04' | 127°03' | 540 |
| Boseong | 34°49' | 127°12' | 160 |
| Yeongam | 34°49' | 126°42' | 50 |

Table 2. The location of three test sites of *Q. acutissima* provenance trials.

| Test site | Latitude (N) | Longitude (E) | Altitude (m) |
|---|---|---|---|
| Whaseong, Geonggi province | 37°17' | 126°56' | 100 |
| Chungju, Chungbuk province | 36°53' | 127°57' | 160 |
| Jinju, Geongnam province | 35°08' | 128°18' | 70 |

Table 3. Stability parameters of *Q. acutissima* provenances.

| Provenance | Survival rate | | | | Height growth | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | b*i* | $r^2$ | $S^2d$ | Mean | b*i* | $r^2$ | $S^2d$ |
| Gangwha | 78.1 | 0.55 | 0.86 | 7.5 | 331.5 | 0.69 | 0.82 | 25.9 |
| Heongseong | 70.0 | 1.62 | 0.94 | 109.4 | 331.8 | 0.95 | 0.87 | 5.1 |
| Wonju | 69.3 | 0.73 | 0.57 | 6.5 | 309.5 | 0.81 | 0.77 | 3.8 |
| Hwaseong | 62.3 | 1.11 | 0.89 | 5.4 | 337.9 | 0.84 | 0.90 | 6.2 |
| Namyang | 76.0 | 0.98 | 0.74 | 41.0 | 640.5 | 0.73 | 0.87 | 4.4 |
| Eumseong | 68.0 | 0.84 | 0.86 | 8.0 | 313.1 | 1.69 | 0.91 | 145.1 |
| Joongwon | 74.7 | 1.13 | 0.96 | 12.3 | 310.2 | 1.18 | 0.86 | 17.8 |

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|---|---|---|---|---|---|---|---|---|
| Geosan | 77.8 | 0.64 | 0.97 | 5.3 | 321.2 | 1.36 | 0.88 | 55.4 |
| Yeongi | 71.7 | 1.23 | 0.95 | 17.4 | 337.8 | 1.06 | 0.76 | 1.0 |
| Cheongyang | 60.3 | 0.99 | 0.86 | 5.4 | 292.8 | 0.85 | 0.85 | 2.0 |
| Buyeo | 77.0 | 0.86 | 0.90 | 5.7 | 309.2 | 1.07 | 0.85 | 9.1 |
| Okcheon | 82.0 | 0.84 | 0.86 | 8.0 | 320.7 | 1.08 | 0.96 | 5.0 |
| Keumreung | 73.0 | 1.13 | 0.96 | 12.3 | 313.4 | 0.84 | 0.89 | 4.5 |
| Chilgok | 62.7 | 0.64 | 0.97 | 5.3 | 302.7 | 1.06 | 0.93 | 6.6 |
| Hwasoon | 79.7 | 1.01 | 0.96 | 6.3 | 357.7 | 1.27 | 0.86 | 25.4 |
| Boseong | 77.7 | 1.16 | 0.99 | 3.6 | 319.2 | 1.18 | 0.91 | 68.8 |
| Yeongam | 72.3 | 0.79 | 0.50 | 12.8 | 343.8 | 1.02 | 0.89 | 16.6 |

**References Cited**

Cho, M. Y. 1989. Colored Woody Plants of Korea. Academic Inc., Seoul. 498pp.

Finlay, K. W. and G. N. Wilkinson. 1963. The analysis of adaptation in a plant-breeding programme. Aust. J. Agric. Res. 14: 742-754.

Gwaze, D. P., J. A. Wolliams, P. J. Kanowski and F. E. Bridgwater. 2001. Interaction of genotype with site for height and stem straightness in *Pinus taeda* in Zimbabwe. Silvae Genetica 50: 135-140.

Yeiser, J. L., W. Lowe and J. P. van Buijtenen. 2001. Stability and seed movement for loblolly pine in the western gulf region. Silvae Genetica 50: 81-88.