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# On the Growth of the Surface Area of Isolated Young Trees, *Alnus tinctoria* Sargent

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## 산오리나무 孤立木의 表面積成長에 對하여

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## ABSTRACT

Six young trees of *Alnus tinctoria* grown in isolation, each having different growing stage, were selected and the surface area of their roots, stems and leaves was determined. Each of the roots of more than 0.2mm in diameter and stems was cut at intervals of 10cm and their surface area was calculated with $2\pi rl$ from the average diameter (2r) of both sections (upper and lower) by making cylindrical estimation of the cut pieces. The leaf area measured was only one side area, and the volume of cut piece and amount of dry matter of each organ were also measured.

The percentage to the surface area of the whole plant body by each organ was 4–12% in root, 7–9% in stem and 69–89% in leaf, respectively. There was relatively a little individual difference. However, the surface area ratios of root and stem showed a slightly increasing tendency while that of leaf decreasing according to the growing stage.

The ratio of sum leaf area index (LAIi) was 2.3–4.0$m^2/m^2$ and that of the surface area index (SAIi) was 0.16–0.33$m^2/m^2$, respectively. It has been known that the stem surface area (SAI) to the leaf area index (LAI) is within the range of 31–53%, but the SAIi is within the range of 8–11% of the LAIi.

## INTRODUCTION

Since plant community is formed by structural and functional integration of many individuals, the investigation of structural or functional difference between individuals in isolation and in community may be a way to understand plant community. According to Cockshull and Hughes (1968), an individual of plant community is different from others in light requirement especially, among various factors, affecting the distribution of dry weight. If the distribution of dry weight by organ changes, an individual of plant community is differed naturally from an isolated individual in tree form.

A plant or a stand is treated at a set of unit pipe in the pipe model theory (Shinozaki, et al., 1964) induced from the discussion on the productive structure of plant community. According to this concept, plant and stand are the same in a set of unit pipe. In this case, the difference between plant and stand is the separation of each unit pipe

in stand while plant seems to form trunk in bundle of unit pipe. Even in case that specific pipe length is the same as that of the separated one in the unit pipe which forms a bundle, the surface area covering the unit pipe should be considered, from the theoretical point of view, to be saved. It can be presumed, therefore, that the distribution ratio of surface area by organ may be different between individual and plant community.

The ratio of surface area of the shoot and root system of plant has been a problem of great concern for a long time(Parker, 1949). Although many reports are available on the leaf area in relation to the primary production of plants, data concerning the investigation of the surface area of root and stem are rarely available. It is necessary to investigate the surface area of root and stem because of its relationship with the respiration rate, energy exchange and water and mineral budgets. However, it seems that the distribution of surface area in plant community was more concerned (Whittaker and Woodwell, 1967; Yim et al., 1969) than in the isolated individual. Even the estimation of dry weight of subterranean organs is very difficult (Melhuish, 1968; Fiala et al., 1968) and therefore there is almost none of reliable information concerning the surface area of the isolated individuals.

From this point of view, it is intended to discuss about the change of surface area along with the growth of isolated *Alnus tinctoria* and the difference in the surface area of plant body at the individual and community levels related to such a change.

## MATERIALS AND METHODS

1. Selection of sample trees

Six young trees of *Alnus tinctoria*, isolated on a hill at Iljuk-myon, Kyunggido Province, and not affected externally liable to cause ecological imbalance, were selected.

The sampling of *Alnus tinctoria*, a species usually used for afforestation, was made between June 15 and July 25, 1972 when its leaves were completely developed. The soil on which the sample trees grown was formed with sandy loam and almost no difference in its appearance was observed among six sites.

2. External characteristics and surrounding conditions of the sample trees

The external characteristics and microhabitat of the six sample trees, *Alnus tinctoria* are as summarized in Table 1.

3. Measurement of surface area, dry matter amount and volume

The sample trees were cut at intervals of 10cm from the ground and the leaf, stem and root areas were measured by each zone. The surface area was calculated with $2\pi rl$ from the average diameter ($2r$) of the upper and lower sections and the length of cut pieces by making cylindrical estimation of the root (more than 0.2mm in diameter) and stem. The surface area of leaf was measured on only one side by transferring the leaf form to tracing paper and counting of 0.25 square mili-

**Table 1. Summary of some quantitative characteristics of the sample trees, *Alnus tinctoria***

| Sample tree | Height (cm) | Diameter of $H_{30}$ (cm) | Covering area of shoot(cm ) | $H_{max}$ (cm) | Depth of root (cm) | Covering area of root (cm ) | $D_{max}$ (cm) | Sampling date |
|---|---|---|---|---|---|---|---|---|
| A | 75 | 0.7 | 1970 | 41.4 | 38.8 | 412 | 4.8 | July 25 |
| B | 100 | 0.8 | 4704 | 45.2 | 47.5 | 996 | 6.5 | June 18 |
| C | 132 | 1.5 | 8617 | 40.6 | 33.8 | 2887 | 18.9 | July 16 |
| D | 169 | 2.1 | 15300 | 46.2 | 53.1 | 19717 | 41.5 | July 9 |
| E(1) | 176 | 3.4 | 22220 | 89.8 | 105.0 | 12269 | 47.0 | June 15 |
| F(2) | 246 | 4.6 | 17718 | 148.0 | 67.8 | 41845 | 21.0 | July 2 |

$H_{30}$: Stem of 30cm high above the ground.
$H_{max}$ Height to canopy of the widest covering area on the ground.
$D_{max}$: Depth of root system of the widest covering area.
(1) Two small lower branches showed the marks of being picked.
(2) Four small lower branches showed the marks of being picked.

meters on milimeter paper(Ondok, 1968).

The sections of plant samples were dried in an oven of 80–85°C for 3–4 days and its dry matter amount was obtained subsequently. The volume of plant body was also measured by each zone by using a water contained cylinder. Various methods were employed to measure the root area in order to solve difficult technical problems involved. However, it is not considered possible practically to obtain a significant area for root activity with such macro method described above (Melhuish, 1968). The measuring method for the present study was adopted as a scheme to aquire the first-hand knowledge about the surface area.

## RESULTS AND DISCUSSION

As shown in Tables 2,3 and 4, the surface area, dry weight and volume by each organ of plant body increase along with the plant growth. When these measurements are reviewed in terms of percentage by organ to the whole plant body, the dry weight and surface area increases slightly in root and stem while that of the leaf area decreases slightly and a marked decrease in the dry matter of leaf along with the plant growth. These phenomena may be interpreted to be resulted by the accumulation of non-living substance in root and stem as the plant grows. The function of the unit surface area by each organ can not be concluded to be identical, and therefore comparison is difficult to be made with only the absolute value of the area. However, assuming that the shoot and root system maintain apparently

**Table 4. Volume by each organ of the sample trees (cc)**

| Sample tree | Stem | Root | Total |
|---|---|---|---|
| A | 76.0 | 28.7 | 104.7 |
| B | 145.1 | 45.7 | 190.8 |
| C | 268.1 | 133.2 | 401.3 |
| D | 691.5 | 251.7 | 943.2 |
| E | 1260.6 | 611.2 | 1871.8 |
| F | 1075.1 | 791.9 | 1867.0 |

**Table 5. Distribution of surface area (Sa) and dry matter (Dw) in each organ per plant (%)**

| Sample tree | | Root | Stem | Leaf | Total |
|---|---|---|---|---|---|
| A | Sa | 4 | 7 | 89 | 100 |
| | Dw | 17 | 42 | 41 | 100 |
| B | Sa | 4 | 8 | 88 | 100 |
| | Dw | 15 | 44 | 41 | 100 |
| C | Sa | 5 | 7 | 88 | 100 |
| | Dw | 20 | 40 | 40 | 100 |
| D | Sa | 4 | 8 | 88 | 100 |
| | Dw | 17 | 46 | 37 | 100 |
| E | Sa | 4 | 8 | 88 | 100 |
| | Dw | 23 | 43 | 34 | 100 |
| F | Sa | 12 | 9 | 79 | 100 |
| | Dw | 29 | 43 | 28 | 100 |

**Table 2. Surface area of each organ of the sample trees ($cm^2$)**

| Sample tree | Root | Stem | Leaf | Total | Stem & root | Stem & leaf |
|---|---|---|---|---|---|---|
| A | 392.9 | 611.5 | 7903.2 | 8907.6 | 1004.4 | 8514.7 |
| B | 568.1 | 1134.1 | 11732.4 | 13434.6 | 1702.2 | 12866.5 |
| C | 1301.7 | 2184.5 | 26425.8 | 29912.0 | 3486.2 | 28610.3 |
| D | 1829.5 | 4417.5 | 47505.4 | 53752.4 | 6247.1 | 51922.9 |
| E | 3401.0 | 5009.5 | 52171.1 | 60581.6 | 8410.5 | 57180.6 |
| F | 6398.6 | 4410.0 | 40422.0 | 51230.7 | 11808.6 | 44832.0 |

**Table 3. Dry matter amount of each organ of the sample trees (g)**

| Sample tree | Root | Stem | Leaf | Total | Stem & Root | Stem & leaf |
|---|---|---|---|---|---|---|
| A | 16.5 | 39.1 | 38.6 | 94.2 | 55.6 | 77.7 |
| B | 29.7 | 86.9 | 80.5 | 197.1 | 116.6 | 167.4 |
| C | 77.4 | 151.4 | 146.1 | 374.9 | 228.8 | 297.5 |
| D | 129.7 | 348.6 | 281.0 | 759.3 | 478.3 | 629.6 |
| E | 292.9 | 538.9 | 427.8 | 1259.5 | 831.7 | 966.7 |
| F | 378.0 | 558.5 | 363.6 | 1299.1 | 936.5 | 921.1 |

functional balance as in water economy of plant body, the vitality per unit area may be roughly evaluated from the ratio of area by each organ.

There are some noticeable facts in the ratio of surface area by each organ as described hereunder.

The ratio (Sa/Ra) of the stem surface area(Sa) to root surface area (Ra) is within the range of 0.7–2.4. No symmetrical ratio was observed due to the fact that the root of less than 0.2mm in diameter is excluded in the measurement of the root surface area and the actual root surface of activity and stem is not identical. Moreover, the ratio (Sa+La /Ra) of stem and leaf surface area (La: one side only) to the root surface area in the best stage of foliage is within the range of 7–22. This indicates a great difference which may be explained as a dynamical difference of activity between roots, which absorb water in the soil, and shoot which transpires as a vapor from water.

The ratio of sum leaf area to the land area occupied by one isolated tree was considered on the same basis as the leaf area index (LAI); i.e., the leaf area index of isolated tree is expressed in LAIi and the stem surface area index of isolated tree similar to the surface area index (SAI) is expressed in SAIi. Then the LAIi and SAIi are within the range of 2.3–4.0$m^2/m^2$ and 0.23–0.33$m^2/m^2$, respectively. The LAIi and SAIi show a decreasing tendency along with the plant growing stage especially it can be seen that the SAIi is within the range of about 10–20% of 1.6–2.7$m^2/m^2$ (Whit taker & Woodwell, 1967) or 1.5–2.8$m^2/m^2$(Yim, et al., 1969) of the SAI reported at the level of plant community.

It has been reported that the SAI is within 31–53% range of the LAI, but the SAIi is within 8–11% range of the LAIi. This indicates that the foliage is developed relatively because of favorable light receiving condition of isolated tree. Reviewing the fact that the SAIi/LAIi becomes smaller than the SAI/LAI, based on the pipe model theory (Shinozaki, et al., 1964), specific pipe length can be substituted for stem surface area in an identical tree form. In addition, the decreasing tendency of either LAI or SAI along with the growth of isolated trees even from the theory of leaf area density (Kira, et al., 1970). Therefore, it may be a difference resulting from whether the uint pipe is formed in bundle like a tree or separated as in the plant community. It may be considered to be different in part from the change of specific pipe length which is presumed to be attributable to sparse density of tissues according to planting density and growing stage in the herbaceous plant, thickening growth of which is not apparent.

It is difficult to measure accurately the surface area of plant body, and therefore various methods have been employed (Ondok, 1968). However, most of these methods need a lot of time and involve technical difficulty. It seems to be possible to estimate the surface area with volume or dry matter which is readily measurable for comparison between the individual or community.

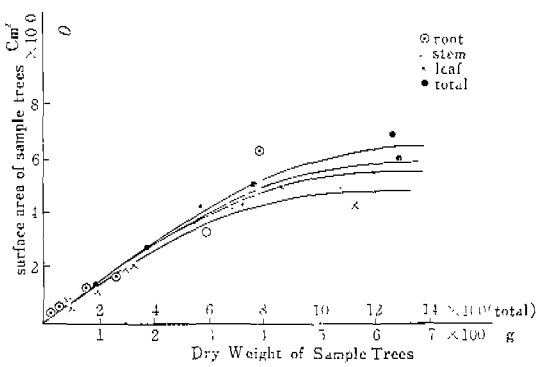


Fig. 1 Relations between dry weight and surface area of sample trees.

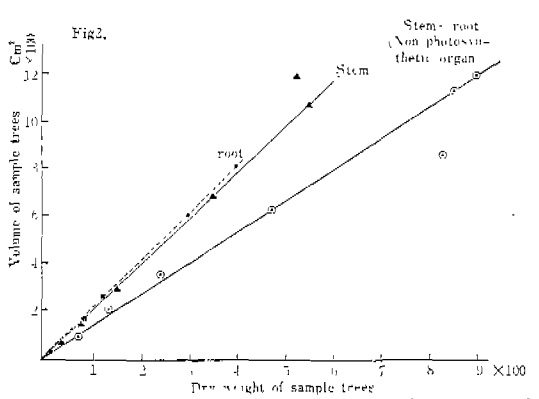


Fig. 2 Relations between dry weight and volume of sample trees.

## 摘 要

植物體의 表面積은 光合成, 呼吸速度, energy 交換, 물과 無機物의 收支와 關係있는 重要한 것이지만 이에 對한 資料는 아직 不足하다. 特히 뿌리의 表面積은 測定의 困難性때문에 그 大綱을 把握하기 조차 어려운 實情이다.

*Alnus tinctoria*의 孤立해서 자란 成長段階가 各己 다른 6本의 稚樹를 選定하여 뿌리, 줄기, 잎의 表面積을 測定하였다. 줄기와 直徑 0, 2*mm* 以上의 뿌리를 各各 10*cm* 間隔으로 잘라 이것을 圓柱에 近似시켜 길이(*l*)와 兩端의 直徑(長徑과 短徑)의 平均値(2r)르부터 $2\pi rl$로 表面積을 算定했다. 잎의 面積은 한 쪽의 兩積만을 測定 表示했다. 그 밖에 乾物量과 體積을 測定했다.

各 器官別 表面積의 植物體 全體의 表面積에 對한 百分比는 뿌리가 4~12%, 줄기는 7~9%, 잎은 79~89%로서 比較的 個體差가 적었으나, 成長 段階에 따라서 뿌리와 줄기의 表面積(%)은 若干의 增加傾向을, 잎의 그것은 減小傾向을 나타냈다.

한 孤立木이 덮고 있는 地面積에 對한 總葉面積比, 即 孤立木의 葉面積指數(LALi)는 2.3~4.0 $m^2/m^2$, 그 줄기의 葉面積指數(SAIi)는 0.16~0.33 $m^2/m^2$이었다. 또 이제까지 葉面積指數(LAI)에 對해서 葉面積(SAI)은 31~53% 範囲로 알려져 있는데, SAIi는 LAIi의 8~11% 範圍에 있어 SAIi/LAIi는 SAI/LAI의 20~25%임을 알 수 있었다.


## REFERENCES


Cockshull, K.E. and A.P. Hughes 1969. Growth and dry weight distribution in *Callistephus chinensis* as Influenced by lighting treatment. Ann. Bot. 33. 367–79.

Fiala, K., D. Dykyjova, Kvêt. and J. Svoboda 1968. International Symposium USSR, Methods of productivity studies in root system and rhizosphere organisms.

Kira, T., K. Shinozaki and K. Hozumi 1969. Structure of forest canopies as related to their primary productivity. Plant & Cell Physiol. 10. 129–142.

Melhuish, F. M. 1968. A precise technique for measurement of roots and root distribution in soils. Ann. Bot., N.S. 32. 15–22.

Ondock, J. P. 1968. Measurement of leaf area *in Phragmites commuis Trin.* Photosynthetica 2 (1). 25–30.

Parker, T. 1949. Effect of variations in the root-leaf ratio on transpiration rate. Plant Physiol. 24. 739–743.

Shinozaki, K., K.Yoda, K. Hozumi and T. Kira. 1964. A quantitative analysis of plant form—the pipe model theory, 1 Basic analyses. Jap. J. Ecol. Vol. 14, No. 3. 97–105.

Whittaker, R. H. and G. M. Woodwell 1967. Surfase-area relation of woody plants and forest communities. Amer. J. Bot. 54 (8) 931–939.

Yim, Y. J., H. Ogawa and T. Kira 1969. Light Interception by stems in plant communities. Jap. J. Ecol. Vol. 19, No. 6. 233–238.


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